# TRANSACTIONS

## OF THE ILLUMINATING ENGINEERING SOCIETY

"..... the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto"

*Featuring*

The Year's Progress in Illumination

Lighting the Silk Industry with Incandescent Lamps

By H. W. Desaix

VOL. XVIII. SEPTEMBER, 1923 NO. 7

SEVENTEENTH ANNUAL CONVENTION, I. E. S.

LAKE GEORGE, N. Y., SEPT. 24-28, 1923

# TRANSACTIONS
## OF THE
## ILLUMINATING ENGINEERING SOCIETY

Vol. XVIII SEPTEMBER, 1923


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TRANSACTIONS
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ILLUMINATING ENGINEERING SOCIETY

VOL. XVIII SEPTEMBER, 1923 NO. 7

## The Coming Convention at Lake George, N. Y.

LAKE GEORGE, "Queen of American Lakes," has been chosen as the place for the 1923 Convention of the Illuminating Engineering Society. This particularly happy selection will afford delegates to this year's meeting opportunities to combine business and pleasure amid incomparable scenery and ideal climate with all the adjuncts of diversified recreation. The Convention dates are September 24 to 28 inclusive. Special plans for the entertainment of the ladies are being made including boat rides on the lake, bridge, dancing, etc. An elaborate program of spectacular lighting and fireworks is also scheduled.

The Fort William Henry Hotel, Convention Headquarters, is one of the show places of this section. Situated at the south end of the lake it is near the site of old Fort William Henry, rich in historical lore connected with the early settler days and on the site of many bloody battles between the white man and the Indians. Lake George is at an altitude of 331 feet and is 70 miles from Albany. A beautiful motor trip from Albany or Schenectady is afforded through some of the most imposing scenery to be found south of the Adirondacks proper. Lake George in fact is the southern gateway to the Adirondack Mountains.

It is bordered on both sides for miles of its forty mile course with high wooded hills and towering cliffs. Dotted with many islands and innumerable bays, a vast panorama of sky, land and water greets the visitor from the wide veranda of the hotel looking up the lake to the north.

Lake George is reached via the Delaware & Hudson Railroad from Albany which road also operates the commodius steamers that ply up and down the lake. At the head of the lake are the ruins of famous Fort Ticonderoga. It is indeed a land abounding in profusion of natural beauty, a land of great scenic attractions, history and romance and alluring charm.

The Convention comes at a time when the full glory of the autumn foliage should be in evidence adding new colors to a spot which has aptly been called a Summer Paradise.

W. D'A. Ryan, *Chairman*

1923 General Convention Committee.

# REFLECTIONS

## The Year's Progress in Illumination

THIS report by the Committee on Progress, presented on page 583 of this issue, covers developments, not necessarily improvements, in the whole field of illuminating engineering as reported in the scientific and technical press. It constitutes what amounts to an annual history of the subject.

## Motor Vehicle Regulations

THE Committee on Motor Vehicle Lighting in the report for the present year summarize their activities. Specifications for rear lamps have been drawn up and adopted, receiving the endorsement of the Society of Automotive Engineers. The Headlighting Specifications have become a tentative American Standard. The Conference of Motor Vehicle Administrators, consisting of the New England, Middle Atlantic States and Ohio, are approving headlighting devices under the Standard Specifications. The California Headlight law is the standard specifications with but slight modification. International relationship has been established through the Committee Chairman with the International Commission on Illumination, and work is in progress with England, France, and Switzerland. No further change can be made in the Specifications except through the Sectional Committee of the A. E. S. C.

## Pageant Street Lighting

THE advent of the new spray-colored or diffusing bulb Mazda lamps has made possible some remarkable decorative effects in the spectacular lighting of streets for pageants and festivals.

One of the latest and most striking of such engineering accomplishments is described by the author, being the decorations of Washington, D. C., during the National Shriners' Convention of June 1923. This convention paper of extreme interest is contributed by Mr. Samuel G. Hibben of the Westinghouse Lamp Co. of New York City.

## Preliminary Studies in the Response of Plants to Artificial Light

SEVERAL thousand vegetable seedlings raised in flats and a larger number of flowering plants started from cuttings, raised in pots, were placed under ten 500-watt, 110-volt Mazda C clear lamps from March 1, 1923 to April 4, 1923. The lamps were turned on at 9:00 p. m. and automatically shut off at 2:00 a. m. during the five weeks of the test. In addition to the artificial light the plants were exposed to sunlight. Check plants under sunlight only were duplicated in size and variety. As a result the plants under artificial light grew more rapidly and the flowering plants bloomed approximately 8 days earlier than the check plants. The chemical tests show approximately the same amount of chlorophyll in both groups of plants. A progressive series of illustrations as well as curves plotted on charts show the remarkable growth and production of forced plants.

Light, one of the most important external factors in the growth of the plant, may in a few years be supplied economically to the commercial grower which will mean that the crops, both vegetables and flowers will be raised in a shorter period, that there will be earlier productions in the spring and also in the bringing of the crops in on scheduled dates.

The author of this paper Prof. R. H. Harvey of University of Minnesota, has carried on an investigation which will prove very fruitful.

## Carbohydrate Production and Growth in Plants Under Artificial Light

THE optimum conditions of light intensity for the growth of a great variety of plants have been determined using continuous artificial light. The intensity requirements of many plants is such that growth in artificial light alone is practicable in northern regions where winter sunlight is low and unreliable. Plants such as Easter Lilies can be speeded up in time of blooming to bring them into the market at a certain date. The use of artificial light makes it possible to force blooming of two varieties at the same time so that hybrids may be more easily produced. There is a correlation between the intensity of continuous illumination and the quantity and nature of the carbohydrates produced in photosynthesis. The production of male or female flowers by some dioecious plants is dependent upon light intensity.

This convention paper is a result of an investigation conducted at Columbia University under the direction of Prof. Hugh Findlay and should be extremely interesting to layman as well as the illuminating engineer.

## Some Experiments on the Speed of Vision

THE question of the time required for light to make an adequate visual impression has recently become of fundamental interest to industrial lighting.

This "time of impression" will depend upon many conditions of vision, such as: (a) the size and distance of the object; (b) its brightness compared with that of its backgrounds; (c) the general level of brightness; (d) whether vision of form is necessary, or the simple "picking-up" of the object, and; (e) the reduction in effectiveness of the image of the object due to images of other objects seen immediately before and after it.

The working out of a complete law of the "speed of vision" will be a tremendous task, when representative variations of each of these factors have been considered. The present paper is a contribution to this work, and shows in what way the speed of impression of the eye changes with change in the brightness-level, under various conditions as to the size of the test-object, as to the necessity for seeing form as against the simple recognition of the presence of the object, and as to the presence or absence of confusion due to the images of other objects seen immediately before and after the test-object.

Dr. Percy W. Cobb has contributed an interesting paper, which is of value to industry at large.

## Depreciation of Lighting Equipments Due to Dust and Dirt

IN this convention paper Mr. E. A. Anderson set forth a report of tests under service conditions to determine the relative depreciation or loss in efficiency of lighting equipments due to the accumulation of dust and dirt. Comparison tests were made under forced rates of dirt accumulation in an effort to determine the feasibility of obtaining quick comparisons between the depreciation rates of different equipments. Consideration of the possibilities of a simple comparison standard for predicting depreciation rates in a particular installation is included.

## Further Studies of the Effect of Composition of Light on Important Ocular Functions

IN a paper presented to this Society in 1921 results were given showing the eye's acuity, speed of discrimination, and power to sustain acuity for spectrum lights of a high degree of purity, made equal photometrically at the test surface. The efficiency of the eye with regard to these three important functions was found to be greater in the mid region of the spectrum than towards either end. Spectrum lights equalized as to brightness, however, show a considerable difference in saturation. It became important, therefore, to determine whether the difference in the results obtained should be ascribed to differences in saturation or whether, for example, some hues are more favorable than others as a background for the discrimination of black test letters or printed characters. In the present investigation the spectrum lights were equalized both as to saturation and luminosity and the tests repeated for the same observers. An advantage, not so great but still considerable, was found for lights in the mid-region of the spectrum.

The investigation was supplemented by the fatigue test used in our earlier investigations. That is, the power to sustain a acuity was obtained before and after three hours of reading with the page illuminated by red, yellow, green, and blue filtered lights (dipped lamps), equalized in luminosity and saturation at the point of work. A comparison of the results before and after reading shows that the eye held its power to sustain clear seeing best under the yellow light. The test surface and reading page were illuminated by the same light and were carefully matched for each color in hue, saturation and brightness. A spectrophotometric analysis was made of the light reflected from the reading page. The yellow light was found by test also to show the least tendency to produce discomfort.

This convention paper is a continuation of a series of studies by the well known authorities, Dr. C. E. Ferree, and Dr. Gertrude Rand of Bryn Mawr College.

## Artificial Illumination in the Iron and Steel Industry

THE convention paper, by Mr. W. H. Rademacher, describes an interesting phase of illuminating engineering.

During the last decade the application of artificial light in the Iron and Steel Industry has undergone marked changes with a distinct trend toward betterment. The modern incandescent lamp has rapidly displaced other forms of illuminants and in conjunction with modern reflecting equipment is today recognized standard. Altho much of the work involved in this industry is of a rough nature and does not necessitate lighting intensities of a relatively high magnitude, the requirements are nevertheless far from important. Chief among the credits to the account of modern lighting are safety insurance and the twenty-four hour day, attended by the successful coping with keen competition and the affection of economies in production.

The selection and application of equipment for the various areas embraced in plant structure are exceptionally important problems, dictating as they do the success or failure of the resultant illuminating effect.

In this paper the requirements of the various sections and operations are treated in detail, recommendations being offered as to the best practice. Photographs illustrating the application of the modern principles discussed accompany the text.

## Railway Car Lighting

THE subject of Railway Car Lighting is treated in an excellent manner by Mr. G. E. Hulse. Limitations encountered in the problem of supplying illuminations to cars. Amount of energy available limited, due to car being on the move. Position of lighting fixtures determined by car construction, preventing flexibility in placing units.

Maintenance of reflecting and transmitting surfaces more difficult than in most other situations.

*Means of Lighting—*

Gas—incandescent mantle.

Electricity—axle driven generator with storage battery.

*Standardization of Car Illumination—*

The postal car lighting tests of 1912 determined and standardized.

The amount of illumination necessary for postal clerks to properly handle mail.

The types of reflectors best suited for such use.

Based on these test results, the Railway Mail Service issued specifications for lighting of postal cars, giving definite values for their illumination and other details, such as mounting height of lamps, and angle of cut-off.

These specifications can be applied without the necessity of further investigation, in the case of the change in interior design of postal cars, the type of reflector available, or the type of light source available.

*Coach Lighting Tests of 1913—*

Determined the amount of illumination obtained with the possible arrangements of fixtures, and the available types of reflectors, bowls and lamps.

The results of these tests are still in use as the basis for designing lighting installations in practically all classes of cars.

*Arrangements of Fixtures for Various Types of Cars, and the Resulting Illumination—*

Coaches, Dining cars, Sleeping cars, Postal cars, Business cars, Baggage cars, Parlor Smoking cars.

*Types of Glassware Used and the Efficiency of Installation with this Glassware.*

Illumination values obtained. The illumination obtained runs lower than illumination values used in office or factory installations, but seems to be ample for the conditions under which it is used.

## Daylighting from Windows

THIS convention paper, by Messrs. H. H. Higbee and G. W. Younglove appeals to the architect as well as the illuminating engineer.

The purpose of this paper is to present a considerable amount of experimental data covering various points of practical importance and great interest with respect to daylighting of interiors, upon which actual and detailed quantitative information appears to be meagre. The investigations which yielded these data are still in progress, so it is deemed unwise to draw conclusions yet. The data here presented cover actual utilization co-efficient for typical daylight illuminations, together with curves and co-efficients representing distribution of the daylight under a variety of conditions;

also, data on the effect of width of mullions or columns between windows upon distribution of illumination in the room, on the relative effect and efficiency of light from various portions of the window area, on the effect of various methods of controlling the light from windows by means of shades and blinds, and on the effect of dirt accumulations on windows.

## Salient Features in Power Station Lighting

IN a paper to be presented at the 17th Annual Convention, Mr. R. A. Hopkins discusses some interesting problems pertaining the central stations.

Unusual problems are met in the lighting of power stations on account of individual arrangements of equipment, severe service conditions and exacting requirements. The successful lighting system must be reliable, economical, easy to maintain and adequately suited to the specific local requirements which requirements are found to differ throughout the station. The most reliable and economical source of energy is usually the station auxiliary bus. The distribution wiring should be of the particular quality best suited to meet power station conditions and should be designed to give the best possible voltage regulation consistent with economy. An emergency lighting system should be provided and of several possible arrangements the one giving greatest dependability should be selected. All equipment such as cabinets, switches, receptacles, lamps, globes, shades and reflectors should be carefully selected to give maximum operating convenience, long life and high efficiency. A thorough survey of a large number of existing first-class power stations gives data for the solution of a number of typical station illumination problems so selected that the designing engineer may extend the data and conclusions given to meet the requirements of any ordinary station.

## Working with the Architect on Difficult Lighting Problems

IN this paper, the authors, Messrs. Augustus D. Curtis and J. L. Stair, have contributed some interesting problems that appeal to the engineer as well as the architect.

The cost for the lighting of a building is not represented by the cost of the luminaires, but is measured by the satisfactory character of the illumination effects produced in the building.

The necessity for early consultation between the architect and the lighting man in the planning of the lighting features of a building is emphasized as well as the responsibility of the lighting man in developing in himself an appreciation of architectural values so as to most intelligently work with his architectural colleague.

Some specific examples of difficult lighting problems are given to illustrate some of the advantages to be derived by considering the lighting as a component part of the structure.

## The Relation of Illumination to Production

THIS convention paper by Messrs. D. P. Hess and Ward Harrison is a report of extensive tests on the time required for the inspection of parts of roller bearings under various levels of illumination from 5 to 20 foot-candles. Over 7,000,000 separate pieces of material were inspected during the test period. The types of lighting employed as well as the illumination levels were found to have an important bearing on the output of the department. Cost data on the lighting and the value of increased production are included in the paper.

## Some Principles Governing the Proper Utilization of the Light of Day in Roof Fenestration

THE light of day is usually considered a wholesome and vital requirement in our buildings. But it often needs modification, especially with regard to direct sunlight.

Sources of daylight with which the architect has to work are briefly described as regards their intensity, direction and seasonal and diurnal variation.

The usual requirements for natural illumination are outlined and some of the general principles governing the utilization of the latter in roof fenestration set forth—the entering daylight being analyzed as consisting of:

(a) Sunlight directly admitted to the working space.

(b) Light from the sky only, directly admitted to the working space.

(c) Combined light from sun and sky (or from portions of the sky alone) diffusely reflected from adjacent interior or exterior surfaces.

Methods of evaluating each are described, and examples worked out for certain usual types of roof fenestration,—these being divided into the two following general classes:

Class 1. The *one way type* in which the directly entering light comes largely from a single half or side of the "sky dome."

Class 2. The *two way* or *opposed type* in which the directly entering light comes from both halves or sides of the "sky dome." Horizontal roof openings may be considered as an extreme of Class 2.

Some of the advantages and disadvantages of each class are summarized.

The interesting treatment of the use of daylight is contributed by Mr. W. S. Brown.

## Proposed Revised Code of Lighting School Buildings

THE Preliminary Draft of the Proposed Revised Code of Lighting School Buildings will be presented before the Annual Convention at Lake George. It is hoped that a complete discussion of this Code will be contributed by the members present. The Committee on Lighting Legislation, L. B. Marks, *Chairman*, and the Sub-Committee on School Lighting, M. Luckiesh, *Chairman* have assisted in the work of preparing this draft.

The present revision of the Society's Code of Lighting School Buildings is being carried out under the rules of procedure of the American Engineering Standards Committee under the joint sponsorship of the Illuminating Engineering Society and the American Institute of Architects.

Since the code was originally issued in 1918, changes in lighting practice have made necessary a revision of the rules and standards previously adopted. Moreover there has been an insistent demand by school architects, school superintendents and others identified with the lighting of school buildings for more definite specifications in regard to both natural and artificial illumination.

The present revision aims to bring the code up to date and to modify and amplify the rules and text in accordance with experience gained since the original code was issued.

In the proposed revision the code is divided into three parts: (1) *Rules;* (2) *Why the fulfillment of the rules is important;* (3) *How to comply with the rules.*

There are eight rules as in the original draft.

The standards of illumination required have been raised considerably and specifications of definite requirements under the rule relating to glare have been added following the precedent set in the CODE OF LIGHTING FACTORIES, MILLS AND OTHER WORK PLACES (AMERICAN STANDARD). A limiting ratio of maximum to minimum illumination has been set in the rule relating to the distribution of artificial light. Reflection-factors are specified in the rule relating to color and finish of interior. The rule relating to exit and emergency lighting has been made more specific and is based upon the specifications adopted by the Building Exits Code Committee of the A. E. S. C. The subject of blackboards is treated in a separate rule.

## Unit Costs of Industrial Lighting

IN a paper to be presented at the coming Convention, Mr. Davis H. Tuck of the Holophane Glass Co. of New York states that the cost of an industrial lighting system may be divided into two parts. (a) Installation Cost, (b) Operating Cost.

By unit cost is meant the cost per unit of light. The unit adopted is the footcandle per square foot and the unit cost is in cents per foot candle per square foot.

Unit costs of installation and operation of various actual systems of lighting in industrial plants are shown. The value of unit costs is in comparing the economy of installation and operating costs of various types of lighting and in arriving at a quick estimate of the cost of any industrial lighting installation when the area to be illuminated, the foot candle intensity to be obtained and the type of equipment to be used is known.

By a study of the factors entering into the unit costs of installation and operation, it has been possible to materially decrease both the installation and operating costs without sacrificing the quality of the light.

## Colored Lighting

COLORED lighting has assumed a very important position in illuminating engineering in recent years. However, many people are uninformed as to the methods of obtaining color in light-

ing, and the media which are available. In this paper the spectral limits of the various colors are given also the relative luminosity of the various portions of the spectrum from a 150 or 200-watt gas-filled lamp. The characteristics, advantages and disadvantages of various colored media are discussed. These media include colored glass lamps colored glass accessories, gelatine filters, and colored lacquers and spray coatings for lamp bulbs. The transmission factors of many samples of such media have been measured, and are given in this paper. The data show that many of these colored media are much less efficient than they could be in order to produce satisfactory colors. The need for standardization be of such media is very evident from the data given. Two examples of recent large installations of colored lighting are described, with connected-load data. A bibliography of colored lighting is also included.

This interesting convention paper is contributed by Messrs. M. Luckiesh and A. H. Taylor of the National Lamp Works of Cleveland, Ohio.

## The Determination of Daylight Intensity at a Window Opening

THIS convention paper by H. H. Kimball, briefly reviews the Sphotometric measurements of sky brightness, and the determinations of the intensity of daylight on horizontal, vertical, and sloping surfaces, which are given in full in the reports of the Committee for 1921 and 1922. Most of the measurements were made in a comparatively smoke-free suburb of Washington, but some were made in a smoky section of the City of Chicago.

A method of determining the extent of the shading of window openings by neighboring buildings, first given in the report for 1921, is reviewed and extended. The advantage of laying out cities so that the streets run NE–SE instead of E–W and N–S, is pointed out.

Determinations of the reflecting power of surfaces of different kinds, and photometric measurements of their brightness under both cloudy and clear-sky conditions, are also summarized.

The data thus brought together, namely, the brightness of the sky, the intensity of daylight, the shading effect of near-by buildings and other objects, and the reflecting power, or the brightness, of different surfaces, is utilized to compute the intensity of daylight at a window opening under given conditions.

## Recent Developments in Nomenclature and Standards

THIS report of the Committee on Nomenclature and Standards sets forth the progress made during the year in the revision of the "Illuminating Engineering Nomenclature and Photometric Standards" previously prepared by the Committee and approved as American Standard by the American Engineering Standards Committee. This revision has been carried out with a view to making the recommendations of the Committee practicable and applicable in the everyday work of the illuminating engineer. In accordance with this purpose the report presents for consideration several questions on which it is desired to have discussion and the advice of those interested before a final decision is reached.

Among these questions are the definition of the terms "light" and "lighting," the matter of "brightness" and the units to be used in measuring it, and the use of the term "luminaire." The Committee will be glad also to receive any suggestions supplementing the discussion presented at the Convention.

## Testing Colored Material for Fastness to Light

IN this convention paper the author, Mr. H. S. Thayer describes a series of experiments on various colored materials exposed to light sources of different kinds. A number of illustrations are used, consisting of comparisons spectra of the sun, the mercury arc, and the violet carbon arc, and also the commercial form of the violet carbon arc.

Several tables of interesting data, and one set of curves showing variations in the intensity of sunlight with time of lay and season of year, are included.

## Solutions of a Street Lighting Problem

APPROXIMATELY three months ago a letter with a questionnaire and a blue print of the plan and photograph of the street, were sent to a selected list of representative street lighting specialists throughout the country. Eleven solutions of the problem were received which are incorporated in this symposium and should serve as a basis for discussion. These answers were coordinated by the Papers Committee in order that a uniform presentation might be made. The essential data, however, is given exactly as submitted.

## The Visibility of Radiant Energy

A NEW determination of visibility of radiant energy has been made by the Bureau of Standards in co-operation with the Nela Research Laboratories. The step-by-step method was used, n equality-of-brightness method with little or no hue difference in he two parts of the photometric field. The apparatus and method re briefly described. Energy values were based upon radiometric nd spectrophotometric measurements made at the Bureau, check- d by an independent color temperature measurement at the Nela Research Laboratories.

Comparisons are made between the results of the present in- estigation and those previously obtained by the step-by-step and icker methods. A revision of the I. E. S. adopted visibility values s proposed which results in better agreement with the average ex- erimental data and still gives the same wave-length center of ravity for light of a color temperature of 2077°K as is given by ves's physical photometer solution.

This convention paper by Messrs. K. S. Gibson and E. P. T. Tyndall will be equally interesting to the illuminating engineer as ne physicist and is a valuable contribution to the present liter- ture.

## Electric Lights Advance Plant Blooming and Seed Time

VIOLETS in July, poinsettas in August, midwinter irises, dahlias in May, radishes that do not seed, cosmos fifteen feet all and other similar miracles are being produced by the United tates Bureau of Plant Industry as a result of recent experiments nd discoveries of the laws of plant growth, according to . E. Theiss in *World's Work*.

Plants bloom and fruit solely in response to the length of aylight occurring at their normal seasons of maturity, and by sing electric lights to increase the number of light-hours until ney correspond with the number of hours of sunlight at the ason of a given plant's time of blooming, the plant will bring rth blossoms, regardless of the time of year. Conversely, if the ng days of midsummer are made shorter by putting the plant to a dark place after a given number of hours of daylight, the ant will bloom out of season if its normal time of blossoming one of natural short days.

Working with this knowledge, the experts of the Bureau have caused plants to blossom at all seasons of the year; they have advanced and retarded the fruition of vegetables, and by synchronizing the blooming-times of flowers and plants that normally bloom months apart, they have opened a new field for cross-breeding and development of hitherto unknown species.

The value of these discoveries lies in the future, according to Mr. Theiss, who cites experiments with tobacco as showing their commercial importance.

Maryland Mammoth tobacco seedlings grown in hot-houses in Maryland, where the winter days are short, flower when they are no larger than other tobacco plants. Artificial lengthening of the daylight hours produced plants that reached the desired mammoth proportions before seeding, and further experiments showed that if the plants were grown in Florida in winter, the light periods and climate were favorable both for growth and seed production. In other words, the electric lights showed the way for cheap and abundant Florida-grown seed.

"New crops, new things to eat, that are now non-existent and even undreamed of, will as assuredly come as daylight follows dawn," writes Mr. Thiess. "Things we can hardly even imagine, will come from these discoveries of why plants flower and produce fruit."

# PAPERS

## THE YEAR'S PROGRESS IN ILLUMINATION*

1922-1923

### 1923 REPORT OF THE COMMITTEE ON PROGRESS

*"A man may proceed on his path in three ways: he may grope his way for himself in the dark; he may be led by the hand of another, without himself seeing anything; or, lastly he may get a light and so direct his steps."*

—Francis Bacon's "*De Dignitate et Augumentis Scientarium*"

The world of chemistry has been stirred this year by the announcement of the discovery of a new element called "hafnium," which by reason of its position in the periodic table next to the rare earths may prove to be a factor in the great field of light emission. The confimation of Einstein's theory of relativity by data obtained at the last eclipse registers another triumph for astronomy and food for thought for the physicists. But, while a large amount of experimental research work has been going on in those fields in which the illuminating engineer is most interested, and considerable additions have been made to the store of special knowledge in these fields, no new light source has flashed across the horizon, nor have there been any radical changes in the

*A Report to be presented before the Annual Convention of the Illuminating Engineering Society, Lake George, N. Y., September 24-28, 1923. The Papers and Discussions included in our Transactions are not, in general, referred to in this Report, it being taken for granted that members keep themselves advised of the contents of the Transactions.

efficiencies of the light sources in use at present or in the general principles and methods of illuminating engineering.

The phenomena of the arc in gases and metallic vapors have attracted the attention of many investigators and apparently afford great opportunities for the study of those fundamental problems which lie at the very basis of molecular and atomic structure and hence, of the explanation of matter itself. A number of references to work in this field will be found under the heading "Arc and Vapor Tube Lamps".

The physiological action of light both from the standpoint of vision and from that of therapy and biology has also received some attention. Hardly a year passes, and this year is no exception, which does not produce a new theory of vision, while the study of the eye and the mechanism of seeing continues unabated.

Though tables of recommended foot-candle values have been available for sometime for almost all cases of interior illumination, such as school lighting, store lighting, factory lighting, etc., little of a classified character has been heretofore published on values for street lighting. This deficit has now been filled for streets of cities up to 100,000 population. The entire table is too extensive to reprint in the report, but may be found in the original publication. The great strides made in public appreciation of streetlighting are apparent[1] when one reads the following taken from a New England paper of 1816, said to represent the most serious public thought of that date; "(1) A theological objection.—Artificial illumination is an attempt to interfere with the Divine plan of the world which had pre-ordained that it should be dark during nighttime. (2) A medical objection.—Emanations of illuminating gas are injurious. Lighted streets will incline people to remain late out of doors, thus leading to increase of ailments by colds. (3) A moral objection.—The fear of darkness will vanish, and drunkenness and depravity increase. (4) Police objection.—Horses will be frightened and thieves emboldened. (5) Objection from the people.—If streets are illuminated every night, such constant illumination will rob festive occasions of their charm."

[1]Gas Journal, Aug. 2, 1922, p. 270.

The experiments and investigations on the effect on production n various industrial processes of increased illumination are beginning to show results in a quite general tendency toward higher llumination values in recent installations for the lighting of shops nd factories. Additional data have been obtained in this field nd are noted in the report. A very encouraging sign is the wakening of the Government Post Office Department to the mportance of lighting as indicated by the extensive study of ighting conditions in post offices, mentioned in the section on nterior illumination. The duration and apparent thoroughness of he tests give considerable weight to the conclusions and recommendations which may be found applicable to interiors in other ines of business where conditions are correlative.

Further encouragement is to be found in a closer cooperation etween the luminaire industry and the architects' guild.[2] Two epresentatives of the National Council of Lighting Fixture Manufacturers have been appointed on the Structural Committee of the American Institute of Architects. They will work on lighting in onnection with plans for dwellings. In England, a paper on "Illuminating Engineering and the Architect" was read[3] before the Royal Institute of British Architects last fall in which the benefits o be derived from fuller cooperation between these two branches f engineering are strongly emphasized.

In the past the "cost of living" statistics published in Canada[4] ave been misleading in that part referring to lighting, because eating data have been included. Hereafter, these items will be eparated and the result will show a decrease in the average cost f lighting, per family, since 1914. General statistics showing the xtent of electric lighting both for residential and industrial purposes in the United States and the world at large have been made vailable.[5]

The passing of the old cable ship, "Faraday", recalls the fact[6] hat it was one of the first ships to use electric lighting. Arc lamps

[2]Lighting Fixtures and Lighting, Dec. 1922, p. 18.
[3]Electrical Review, Dec. 1, 1922, p. 849.
[4]Electrical World, June 30, 1923, p. 1540.
[5]Electrical Merchandising, Feb. 1923, p. 3082.
[6]Electrician, Mar. 9, 1923, p. 250.

were employed for this purpose when the French Atlantic cable was being laid in 1879.

At several places in the report, material has been mentioned which belongs in previous years but which had not been available to the Committee. In order to make the report as complete a picture of illuminating engineering as possible, it has been decided to include such information with the letters "N. P. R." after the reference to indicate "not previously reported". As usual the Committee has received information from the engineers in charge of lighting in various of the larger cities and the thanks of the Committee are extended to them and to the numerous journals whose pages have been so generously consulted.

Respectfully submitted,

FRANCIS E. CADY, *Chairman*
GEO. S. CRAMPTON
WM. E. SAUNDERS

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## GAS

The origin of the name "gas" has been traced[7] to Jan Babtist Van Helmont of Brussels, among the last of the alchemists and one of the earliest contributors to modern chemistry. He was one of the first to understand that there exist other aeriform bodies differing from ordinary air and stated: "This spirit, up to the present unknown, not susceptible of being enclosed in vessels, not being capable of being reduced to a visible body, I call by the name of 'gas'". It was supposed that Helmont took the name from the Dutch word "geest", but it has been pointed out[8] that a study of the writings of Helmont, which were in Latin, indicates that he took the word from the Greek word "chaos".

Installation of a high pressure gas system in the Ancient Royal Burgh of Culross has aroused some interest as it is claimed that in a coal tar factory there, gas was first made some 140 years ago. The Earl of Dundonald in the course of experiments with the tar noticed the inflammable nature of the vapor during the process of distillation. Later he met Murdock and the subject was discussed. It is believed this was the origin of the scheme for the manufacture of gas which Murdock subsequently developed.

It is said that Fredonia, New York,[9] has the credit of being the first place to use natural gas for lighting purposes. The first well was drilled in 1826, the year Lafayette made a tour of the United

[7]Gas Jour., Dec. 27, 1922, p. 810.
[8]Licht und Lampe, Aug. 24, 1922, p. 406.
[9]Amer. Gas Jour., Sept. 23, 1922, p. 20.

States and the tavern where he was entertained was illuminated by gas piped from this well.

As a result of the fact that superheating of the air and gas in a burner increases the flame temperature considerably, and that the smaller the mantle the greater its light (proportional to the gas consumed), and the greater its strength, there is a growing tendency in England to convert gas lamps from the "universal" size mantle to the superheated cluster type of small mantles.

According to recent statistics,[10] gas is now used in 8,800,000 incandescent burners. In Japan there are reported[11] 1,217,094 installations of gas lighting.

In a paper before the German Illuminating Engineering Society it was stated that changes in the constituents of the gas supplied occasioned by lack of coal during the war period and after, had resulted in a hotter and narrower flame for which prewar mantles were not fitted. Mantles must now be of smaller diameter to insure the fabric being in the hottest part of the flame.

*Calorific Standard*

A second progress report[12] has been made by the Joint Committee on Efficiency and Economy of Gas, of the Railroad Commission of California. The Commission carried out extensive investigations and came to the general conclusion that "in fixing a standard of gas quality to be applicable to all California manufactured-gas plants, the fundamental object to be achieved is to supply gas which will make possible the best service to the consumer at the least cost". The report concludes that the present 570 B. t.u. standard is not the best and that a 550 B. t. u. standard would be more satisfactory. On August 20, 1922[13] the Public Service Commission of New York adopted an order prescribing for gas companies operating in the City of New York B.t.u. standard in place of the obsolete candlepower standard. A monthly average must be maintained of not less than 537 B.t.u. and there must be no daily average of any three consecutive days of less than 525 B.t.u.

[10]Gas Age-Rec., Dec. 16, 1922, p. 828.
[11]Gas Jour., June 20, 1923, p. 744.
[12]Gas Age-Rec., Dec. 16, 1922, p. 819.
[13]Am. Gas Jour., Jan. 27, 1923, p. 70.

*Burners*

The Bureau of Standards[14] is conducting tests on the development of a standardized gas burner for dwellings. Improvements in gas burners[15] used for street lighting have been made in England. It was found that the "intermediate" mantle was the most economical one to use considering the amount of light required and the breakage due to vibrations from the heavy motor-truck traffic. Further, with the "intermediate" mantle, it is much easier to adjust the flow so as to get a higher efficiency than is possible with the "universal" mantle. A burner using two mantles has the centers of the mantles and the bunsen tube in one straight line and this arrangement was found to be well adapted for use in conjunction with automatic controllers. The same type is used for burners equipped with three to six mantles, except that where more than two are employed, the outlets are arranged in zig-zag fashion. This facilitates replacement in case of breakage. Tests have shown an average candlepower of 344 between 0 and 20° to the horizontal in a direction at right angles to the long axis of the burner and an average of 191 candlepower at right angles to the short axis. The burner was consuming 18 B.t.u. per candle hour or 13.76 cu. ft. of 450 B.t.u. gas. These results should be compared with those from a six-light circular cluster of the old type which gave an average of 250 candlepower between 0 and 20°. The new type tends to concentrate the light in two directions,—namely, up and down the street. To assist in the development of a maintenance scheme, the burner parts have been worked out so that there shall be interchangeable component parts such as gas-nipples and adjustors, air regulators, bunsen tubes, etc. capable of being assembled in various sizes to make up any particular burner desired.

Experiments to determine how much light from one mantle is cut off by the opacity of an adjacent mantle showed[16] for the particular mantles tested that one allowed 19 per cent of the light of the other to pass through. This would obviously depend on the texture of the mantle. An investigation has been made[17] on the

[14]Am. Gas Jour., Sept. 23, 1922, p. 20.
[15]Gas Jour., Mar. 7, 1923, p. 614.
[16]Gas Jour., Mar. 7, 1923, p. 614.
[17]Licht und Lampe, Aug. 24, 1922, p. 403.

effect of the mass of the primary air on the luminosity and gas consumption of inverted burners, keeping the other conditions constant and only changing the amount of the primary air. The experiments indicated that the luminous intensity depends on the gas consumption and corresponding temperature of the gas flame.

*Mantles*

A new element called "hafnium,[18] has been discovered. It appears to have an atomic weight of about 180 and is chemically allied to the rate earths of the thorium group, to titanium and zirconium. This relationship suggests the possibility of its practical application in the production of gas mantles. A type of silk mantle[19] has been reported which is said to be stronger and more durable than any so far produced. Another new mantle not yet perfected is entirely textureless and yet is said to give the full luminous intensity obtainable from gas by the ordinary means. It consists of finely divided particles of oxide of thorium bound with a soluble salt of that metal and encased in collodion.

It has been found that the ash of incandescent gas mantles emits radioactively in the $\alpha$ and $\beta$ rays.[20] The $\beta$ rays are photographically active and may be absorbed by tinfoil 0.01 mm thick to the extent of 57 per cent. The $\alpha$ rays are strongly ionizing and are absorbed by the same tinfoil to the extent of 84 per cent.

The bump test to determine the resistance to shock of tungsten filament incandescent lamps is a familiar procedure but the testing of the tensile strength of a gas mantle is a much more complicated and delicate task. An apparatus designed[21] for this test comprises a vertical cylindrical float surrounded by water in a circular container. The float carries a cup of melted wax into which the lower edge of the mantle to be tested is placed and the wax allowed to solidify around it. The mantle is thus attached to the float. By running off the water slowly, the mantle takes an increased proportion of the weight of the float which drops when the mantle breaks and automatically shuts off the water. The height of the remaining water is then a gauge of the breaking weight. Test

[18]Sci. News-Letter, Mar. 10. 1923, p. 6.
[19]Gas Jour., Mar. 21, 1923, p. 751.
[20]Chem. Zentralbl., Feb. 22, 1922, p. 440. N. P. R.
[21]Proc. Phys. Soc. of London, Dec. 15, 1922, p. 46.

ave shown that some mantles can support five hundred times heir own weight.

The development of a mantle[22] for use with acetylene gas has een slow in spite of many experiments. Some success has been ttained with high pressure burners but to make a mantle last oo to 600 hours, chemically well-purified acetylene was necessary. mantle has been reported which is designed to insure complete ombustion of either purified or crude acetylene and not to car- onize under any operating pressure. The burner consists of four arts; a tip screwed into a mixing tube on which is screwed a cap ith gauge carrying the mica chimney and mantle, the whole aving a height of 4½ inches. In the jet is screwed a four-hole isk from below bearing a rod; at the upper end is a screw thread nstead of the usual cone entering the orifice plate. This gives a ortex motion to the issuing gas and assists in mixing it with the ir injected through openings in the tube below the level of the rifice. Laboratory tests have indicated an average of 111.6 andles per cu. ft. per hour for burners rated at ⅓ and ¼ cu. ft. r almost six times as much light as from an open flame acety- ene burner.

*Auxiliaries*

A French semi-automatic gas lighter[23] utilizes a pilot light ith independent feed line and a container in which the gas ac- umulates until it reaches a certain pressure. The time required s the time during which it is desired to have the light out. In nother model, the gas is cut off at the source and turned into the nain again when illumination is desired. In either model the ressure of the gas operates a cut-in and cut-out float. In the irst type, provision for extinguishing the light is made by ac- umulating a small amount of the flowing gas until the pressure s right. The time required for this is that during which the light s in operation. The regulating device is contained in a small ylinder attached to the lamp post.

[22]Gas Age-Record, Aug. 5, 1922, p. 178.
[23]Sci. Amer., Feb. 1923, p. 116.

*Kerosene*

A new competitor in the field of portable oil lamps is made i the form of an old fashioned candle and holder. Its fuel is kerosen and it is claimed to furnish 100 hours light from a teaspoonful c the combustible.[24].

## INCANDESCENT ELECTRIC LAMPS

While experimental work on incandescent electric lamps is sti being carried on, there have been no striking developments durin the past year. The following table shows[25] recently compiled dat on the annual and per capita consumption of incandescent lamp in the United States and several foreign countries.

| | Population | Number of Lamps | Lamps per capi |
|---|---|---|---|
| United States | 112 million | 205 million | 1.83 |
| Switzerland | 4 | 6.5 | 1.62 |
| Germany | 57 | 50 | 0.88 |
| France | 41.5 | 30 | 0.72 |
| Austria | 6 | 4 | 0.67 |
| England | 44 | 20 | 0.45 |
| Italy | 40 | 15 | 0.38 |
| Hungary | 7.25 | 2.7 | 0.37 |

For the fiscal year ending June 30, 1923 the government ordere 1,355,000 incandescent filament lamps, a number smaller than fo several years preceding. 85 per cent of this number were larg tungsten lamps as distinct from miniature tungsten and carbor In 1922 the corresponding per cent was 79. 15.4 per cent of th large tungsten lamps were of the gas-filled type. 1706 representa tive lamps were life tested at the Bureau of Standards. Mill-typ tungsten lamps have replaced carbon in Navy work.

*Manufacture*

The demand for carbon lamps[26] has dropped to such an exten that the number sold in 1922 was only about 1.5 per cent of th total number of lamps purchased in that year in the Unite States and only ⅓ the number used in 1920. In the case c tungsten lamps, the distribution according to size and typ has apparently reached a point where differences from year t

[24]Pop. Mech., June 1923, p. 934.
[25]Jour. of A.I.E.E., June 1923, p. 659.
[26]Report of Lamp Committee, N.E.L.A., June 4, 1923.

year are only fractions of a per cent. For the past three years, the vacuum type has composed 79.5 per cent and the gas-filled, 20.5 per cent of the total number distributed, with variations of only 2.2 per cent. The most popular sizes have been the 40-watt, 25-watt, and 50-watt in the vacuum type and the 75-watt and 100-watt in the gas-filled type and this relation has held true for the past three years. However, the 50-watt vacuum lamp has been still gaining. The average efficiency has again increased by about the same percentage as last year and is now 11.5 lumens per watt. The distribution according to voltage shows 88.2 per cent in the 115-volt class with a falling off again in the 230-volt list. The standardization of lamp voltages continues to progress, over 91 per cent of those reported being 115, 110 or 120, in this order of preference.

The growth in the use of miniature tungsten filament lamps has been large in the last few years[27] and in 1922 it reached almost 29 per cent of the total used output (large and miniature). Of this number about 18 per cent were for flashlight service, about 10 per cent for Christmas tree decoration, about 70 per cent for automobile lighting and the rest mainly for signaling purposes.

In the days of the carbon lamp,[28] renewing or refilling burned out lamps was quite a common procedure, but the tungsten filament mounting and treatment is such that the problem was practically dropped except in Germany. A new method has been developed in Italy and is already in commercial use. In this method, the special feature is that all the operations necessary for winding the new filament are carried on outside the lamp to be renewed. The hole in the bulb is made no larger than would be necessary for exhausting an ordinary new lamp. A special mounting of the filament is required and is in the form of a small spiral crown. The arms holding the filament have sufficient resiliency to allow the whole to be folded up with an "umbrella-like movement" when the carrier system is introduced into the bulb.

The importance of the question of international standardization of lamp bases is such that attention should be called to the discussion of this subject under "Reflections" in the April number of the Transactions.

[27]Elec. World, Dec. 23, 1922, p. 1416.
[28]Electrician, May 25, 1923, p. 569.

The use of the iron wire auxiliary to control violent fluctuations in the power supply was a most potent factor in the practicability of the Nernst filament and has been in use to regulate the voltage supply for railway headlights for some time. A foreign experimenter has worked out data[29] from which may be determined the wire necessary to take care of a number of cases.

According to reports from Russia[30] vacuum lamps are now being made at the Moscow lamp works at the rate of 10,000 per month and gas-filled lamps at the rate of 250 per day.

A company has been formed to manufacture in Hungary special types of lamps such as those for Xmas Tree decoration. About 250 million glass bulbs for incandescent lamps are now being produced yearly in Germany.[31] of which 20 per cent are for export. All bulbs are blown individually by hand, operation of the automatic machine having been found to be more expensive than manual labor.

*Types*

In the "mill" type lamp which has an especially rugged construction, a 10 watt size[32] in a straight-sided bulb of either clear or blue glass with a concentrated filament has been developed. It is suggested for use in sign lighting. A lamp is announced from Canada[33] which in a number of sizes is claimed to have a tested life of 1500 hours. No data are presented as to whether this longer life is due to operation at lower efficiency and hence at a lower temperature, or to actual improvements in materials or in methods of construction which would give this life at higher efficiencies corresponding to a 1000 hour life in the lamps as ordinarily manufactured.

A novel application of the electric lamp to advertising sign purposes has appeared in Germany.[34] The lamp has a tubular bulb from 1 to 2 feet long depending on the length of the advertisement. The text of the latter is fitted in blue glass letters in a glass frame in the bulb. Over the lines of the letters, a fine tung-

[29]Rev. Gen. d'Elec., Mar. 24, 1923, p. 477.
[30]Elec. Rev., June 29, 1923, p. 1013.
[31]Zeit. f. Ver. Deut. Ing., May 26, 1923.
[32]Elec. Record, Mar. 1923, p. 162.
[33]Elec. Review, Dec. 29, 1922, p. 992.
[34]Helios, Dec., 24, 1922, p. 4161.

sten filament is laid and kept in position by a small holder. The color of the letters makes them visible by day and the filament illuminates them by night, also furnishing general illumination if desired.

*Properties*

The relationship in incandescent filament lamps between the efficiency and the cost of operation, including the cost of the lamp, was pointed out in the late 90's, but no practical application on an extended scale has come to the attention of this Committee until this year. As a result of a study of the subject, taking into account different power rates and lamp prices,[35] the Hydro-Electric Power Commission of Ontario, Canada, has adopted efficiencies for incandescent lamps for general use on hydro-systems which will result in an average life of 1500 hours. It was found that the rigorous solution of the problem of the most economical efficiency was too complicated for general application throughout the province, and the value decided upon was taken as a compromise.

The experimental determination of the electric and photometric characertistics of tungsten lamps has been extended to the gas-filled type ranging from 50 to 1000 watts. Formulae[36] of the type, $cp = AV^k$, where $A$ and $k$ are constants and *cp.* is the maximum horizontal candlepower, show variations in $k$ from 1.73 to 3.45, the values generally being higher for the higher *cp.* lamps. The 50– and 100–*cp.* lamps were made up with argon gas, the rest with nitrogen. The differences in the values of $k$ were attributed to differences in the purity of the tungsten. The spherical reduction factor (scp/mhc) was found to be 0.978 for the lower *cp.* lamps and 1.04 for the 600– and 1000–*cp.* sizes. The ratio of the resistance hot to that cold ranged from 15 for the 50–*cp.* to 16 for the 1000–*cp.* lamps. Data were obtained on lamps with opal bulbs.

The physical properties at high temperatures of many materials can be studied if they can be mounted in the form of filaments and heated electrically. In such cases, knowledge of the losses due to conduction of heat at the junctions of the leading-in wires and at the supports is desired. The theory of such losses[37] and its appli-

[35] Elec. World, Mar. 17, 1923, p. 645.
[36] Rev. Gen. d'Elec., Aug. 19, 1922, p. 245.
[37] Jour. of Frank. Inst., Nov. 1922, p. 597.

cation to tungsten filaments in a vacuum has been worked out both for long and short filaments. Expressions have been derived for the temperature, resistivity, emission intensity, brightness, and thermionic distributions near a cooling junction for tungsten for the conditions just referred to. The relation of the distribution curves for short filaments to those for long filaments has been obtained and it was found that equations and conclusions developed for cylindrical or wire filaments apply equally well to filaments with rectangular and other cross sections when the proper substitution is made for the radius of the cylindrical filament.

A further study[38] has been made of the rate of evaporation of tungsten in the form of an incandescent filament in a vacuum and in a gas. It was found that at a temperature of 2950°K for the vacuum experiments the rate of evaporation per square centimeter is independent of the diameter from 0.05 to 0.25 mm., but is over 40 per cent greater for fine grained than for very coarse grained wires. In nitrogen, the rate varied from 2 per cent to 5 per cent of that for the same wire in a vacuum and in argon, from 1.3 per cent to 3 per cent greater than in a vacuum.

Specifications to be used in the purchase of incandescent lamps have been published[39] by the Union des Syndicats de l'Electricite in France. For vacuum lamps, the *cp* rating on the bulb is for the maximum intensity in a plane perpendicular to the axis. Lamps are to be tested on three points: quality of materials and conditions of manufacture, candlepower and watt consumption, and life.

### ARC AND VAPOR TUBE LAMPS

Ever since the introduction of the mercury arc and the Moore tube as lighting sources there has been marked interest in this vapor-tube type of light production. The very nature of the source and the character of its construction seem to afford unlimited opportunities for experiment and development. Reference to previous issues of this report will show repeated allusions to research in which lamps of this type are the direct object of the experimental work or a most important auxiliary. Involving as they do luminescence and phosphorescence, the continuous and

[38]Phys. Rev., Mar. 1923, p. 343.
[39]Rev. Gen. d'Elec.. Aug. 26, 1922, p. 277.

ne line spectra with the possibility in the way of a monochro-
atic source of the maximum of luminous efficiency, it is not sur-
rising that they require an increasing amount of space in this
port.

Another contribution to the theory of the electric arc has been
ade,[40] based on a study of the thermionic emission from the
thode, the current carried by positive ions and the cathode fall,
nization in the region between the electrodes and the anode
ll. The view is supported that the arc seems to be dependent
an adequate supply of electrons at the cathode, their escape
om it being made possible by a sufficient ionization of gas near
to form a space charge.

*ypes*

Carbon arc lamps designed especially for moving picture work[41]
ve been brought out for an arc voltage of 160. They are said
burn for 20 hours with one pair of carbons. The result is ob-
ined by an unusually long arc (5 to 6 cm.) burning in its own
mbustion gases in a comparatively small glass globe. By using
e horizontal-light[42] carbon and two vertical auxiliary carbons,
ich conduct current of displaced phase, another arc for pro-
tion use has been announced. Effectively a single phase current
ults and it is claimed that a higher intrinsic brilliancy and less
ker is obtained than with the ordinary two carbon arc. Still
other carbon arc is a reminder of the old Jablochkoff candle.
is a small lamp fitted with an Edison base, has two carbons
ich are parallel and held in a simple but substantial clip sleeve
d the arc is maintained at the points of the carbons by a magnet.
is started by a spark and operates at a current of from 8 to 10
peres. An increase in the life and efficiency of luminous arc
mps[43] has been accomplished by making the electrodes in com-
ssed square or oval cross sections.

Experiments on the size of the cathode spark of the carbon
,[44] have shown that if the anode is placed far enough from the
hode so that its radiation no longer influences the size of the

[40]Physical Review, March 1923, p. 266.
[41]Helios, June 10, 1923, p. 1299.
[42]Elek. Zeit. 44 April 12, 1923, p. 335.
[43]Electrical World, January 6, 1923, p. 27.
[44]Zeit. f. Physik, Oct., 7, 1922, p. 71.

cathode spot, the latter is then proportional to the current strength The constant current density of the spot was found to be 47 amps. per sq. cm. The high frequency alternating-current ar behaves differently from either the low frequency or the spar discharge in that it has a pseudo-stationary range at the middl part of the arc stream.[45]. This conclusion has been derived a the result of stroboscopic experiments on the light emission in th arc stream with various electrodes at a frequency of 6000 com plete periods per second and a current of about 10 amperes. Soli and cored carbon electrodes were employed and tests were als made with rods of Fe, Cu, or Ni as one electrode. For short arc the variation of intensity of the different spectral lines was foun to be very closely in phase with the arc current. In a long arc the part near the electrodes was excluded, the middle region gav a spectrum which would not suffer any variation with the curren oscillation and was as steady as a D. C. arc.

Other experiments on the arc between metallic electrodes wit alternating current indicate that the current passes only fro the hot electrode to the cold whatever the material of which th electrodes are made.[46] By the use of a water cooled electrode ar two other electrodes, a pulsating current, but in a single directio was obtained from a 220 volt A. C. circuit.

*Properties*

Among the physical properties of the carbon-carbon arc[47] is repulsion effect upon the poles. Experiments have shown th this effect increases with the current ranging from 0 to less than dynes for currents up to 20 amperes. It does not vary much wi the arc length but is strongly influenced by the purity of t carbon, metallic salts causing an increase in the pressure on t cathode and a lessening on the anode. Using a spectro-phot meter and the optical pyrometer method, another determinati has been made of the temperature of the crater of the carbon a and other radiation from the flaming arc[48]. The carbons we burned in an automatic projection lamp wherein the electroc were placed at an angle to each other. The temperature was fou

[45]Il Nuovo Cimento, Jan., 1922, p. 59. N.P.R.
[46]Journal de Physique et le Radium, Nov., 1922, p. 389.
[47]Phil. Mag., Oct. 1922, p. 765.
[48]Zeit. f. Tech. Physik, No. 2, 1923, p. 66.

to be dependent on the current strength and the material of the electrodes. Two pure graphite carbons gave the highest black-body temperature. At a normal specified operation of 0.746 amps. per sq. cm. the temperature was 3775° which with the Beck effect ran up to 3900°. The negative electrodes with pure carbon showed the same temperature as the positive crater. Heating the anode to 1100° caused an effective drop of 70° in all colors. In the normal arc a zone of highest intensity occurs just in front of the electrodes. More work on the ultra-violet spectrum of the carbon arc[49] has resulted in a number of lines not previously observed which correspond with prominent lines in the hot-spark spectra studied by Millikan. In addition, values of $\lambda$ have been checked for a number of the prominent lines. Reference should be made to an elaborate discussion[50] of the Goertz-Beck high intensity arc lamp for searchlights which gives data on the spectral distribution, the surface brightness, the rate of burning of the carbons, the influence of the core diameter on the surface brilliancy, etc. as well as information on the mechanical construction of the searchlight unit.

*Mercury Vapor*

Some interest was aroused in technical circles by a report in a French newspaper[51] of a new light source which was said to be in the form of a vacuum tube 6 m. long, 7 mm. in diameter, coated on the inside with a phosphorescent material and exhausted to 0.02 mm. It was said to give a light comparable to that of ordinary sources and a power consumption of only 15 watts. This information was subsequently repudiated[51a] by the French professor who was credited with the invention.

In every form of vapor arc lamp, the elimination of foreign gases from the various parts of the lamp is a necessary step in the manufacture. The effect of such gases in the mercury arc lamp has aroused enough interest to stimulate a research on the subject[52]. Using a spherical glass container 40 cm. in diameter, an investigation was carried out with a discharge which was unstratified and

[49]Proc. of Royal Soc., Jan. 1, 1923, p. 484.
[50]Zeit. f. tech. Physik, No. 4, 1923, p. 138.
[51]Le Matin, March 30, 1923.
[51a]Elec., Apr. 27, 1923, p. 465.
[52]Zeit. f. Physik, May 26, 1923, p. 254.

of medium width and voltage requirement. With the introduction of a foreign gas, the voltage drop increased in proportion as the heat conductivity of the gas was greater than that of the mercury vapor, and in proportion to the increased energy loss of the electrons by collisions of the molecules of the foreign gas. The order of gases with reference to the voltage loss was Hg, Ar, $CO_2$, $NH_3$, N, H, O, $SO_2$. The greater the energy loss by collision just referred to, the greater the voltage required to start the arc.

The mercury arc in quartz can be operated at intensities high enough to give a continuous spectrum in addition to the mercury lines.[53] This effect has been adapted in a compact illuminator especially for monochromatic purposes operating on 110 volts and with either A. C. or D. C. current. The dimensions of the effective light spot are 1.25 x 0.25 inches. A mica filter is provided for observation of the extreme ultra-violet and an adjustable slit and light-tight holder for other filters. With a resistance in series, the lamp operates as a low pressure arc giving only the strongest spectral lines. At full intensity, it changes to a high pressure arc. Additional study from the standpoint of applicability[54] has been made of the quartz mercury arc having an inert gas such as neon, argon, helium, etc. introduced into the tube as described in the 1920 report.[55] A number of models have been constructed suitable for operation on either A. C. or D. C. One D. C. lamp is designed for 115 volt, 4 amperes with a difference of potential at the electrodes of from 80 to 85 volts. The initial current is 11 amperes which falls in 30 seconds to 6 amperes and in 5 minutes to 4 amperes.

On the basis of new experiments on the mechanism of the mercury vapor arc,[56] it has been shown that the anode fall is independent of the current strength and the temperature of the anode as long as the vapor pressure remains constant, and that it is probably influenced by the material of the anode and its form. It has been evaluated both by probe measurements and by measurements of the energy emitted at the anode. The anode fall has been found to approach,[57] with increasing vapor pressure

[53] Jour. of Opt. Soc. of Amer., Dec. 1922, p. 1066.
[54] Revue d'Optique, June 1922, p. 304.
[55] Trans. I.E.S., *15*, 1920, p. 439.
[56] Zeit. f. Physik Feb. 26 1923, p. 378.
[57] Ibid, May 26, 1923, p. 287.

and current strength, a limiting value of 3.72 volts which agrees with the difference between the ionization potential of 10.39 volts and the exciting potential of 6.67 volts. In hydrogen, the anode fall amounts to 17.6 volts and is about 1.2 volts larger than the ionization potential. In argon and neon, the anode fall changes with increasing current strength at the lowest exciting voltage. Data have been obtained[58] on the dissociation temperature and vapor pressure conditions in mercury vapor. A 100-ampere rectifier flask was employed as the arc vessel. In the lower part of the cooling chamber the cross section of the velocity of a mercury vapor jet under full operation was found to be $4.5 \times 10^3$ cm. per sec. The calculation of the temperature in the axis of the positive column gave results which for full load lay between 1000° for a 10-ampere and about 10000° for a 500-ampere rectifier. A study has also been made[59] of the energy dissipation at the cathode spot on the mercury of the cathode.

Data are available on the infra-red radiation from the quartz mercury arc[60] in therange of wave lengths from 0.70 to 4.0$\mu$. Differentiating between the radiation from the quartz tube alone and from the mercury, it was found that the output from the former increased more rapidly than from the luminous mercury and that radiation decreased in intensity throughout the tube in passing from the anode to the cathode. Over a range of from 40 to 120 volts, the mercury radiation formed 30 to 55 per cent of the total and this proportion was increased when the light was filtered through a plate of quartz. The absorption of the fused quartz for mercury radiation was about 38 per cent.

A quiet jet of green vapor plays between and forms the arc stream when mercury is the positive, and carbon the negative electrode of an arc.[61] The jet is always perpendicular to the crater which is a circular depression (3 to 5 mm.) surrounded by an oxide-of-mercury ring. Experiments on the velocity of the stream showed 0 to 30 meters per second. The rate of mercury consumption with known current and crater diameter was also determined. The current density was of the order of 300 to 1000 amps. per sq. cm. The crater area was found to vary directly as the current and the

[58]Ibid, Nov. 17, 1922, p. 260.
[59]Zeit. f. Physik, Oct. 7, 1922, p. 74.
[60]Ibid, No. 6, 1922, p. 353.
[61]Nuovo Cimento, Jan. 1922, p. 31 N.P.R.

variation of voltage with arc length at constant current was approximately linear. In this arc the cyanogen spectral lines are absent. If a meniscus of mercury is used for the anode[62] and a very thin sheet of metal or carbon used for the cathode and the whole properly regulated, the cathode will be punctured and a small flame surmounted by a high tuft of whitish fumes will be seen to play above the hole.

Comparison of the ultra-violet radiation from a quartz mercury arc and the sun at the zenith at Davos, Germany,[63] indicated that at 100 cm. distance, the arc had 3.7 and at 50 cm., 12.2 times the ultra-violet intensity of the sunlight.

*Mercury and other Vapor*

A systematic study of twenty-four illuminating gases[64] when excited by an electrical discharge at low pressure has shown that the light emitted per unit energy consumed varied from 0 in the case of arsenic vapor to 17 candles per watt for sodium vapor. The light was measured from a limited portion of the vacuum tube and the corresponding electrical energy was determined by measuring the potential drop and the current in this part of the tube. The maximum observed efficiencies of neon, mercury, and sodium were 1.8, 10, and 17 mean spherical candles-per-watt respectively. These three proved to be the only elements which gave as high a luminous efficiency as that given by the ordinary illuminants. It was shown that it is very improbable that any gas composed of polyatomic molecules will have high efficiencies.

The fall of potential between electrodes where the cold anode lies within the region lighted by the cathode has been determined for arcs of mercury, zinc, cadmium, and magnesium. For mercury, the value, $9.20 \pm 0.15$ volts was obtained for currents from 5 to 20 amperes; i.e., for this region the fall of potential is independent of the current strength. This was found true for anodes of iron, nickel, and platinum. The zinc arc at small current strengths gave 8.80 and for large currents (10 to 30 amperes) 10.53 volts; the cadmium arc gave 9.9 volts which was constant for currents from 10 to 20 amperes; the magnesium arc showed 12.3 volts for 10 amperes and 12.45 volts for 30 amperes.

[62]Ibid, Oct. 1922, p. 165.
[63]Meteorol. Zs. *39*, 1922, p. 303.
[64]Physical Review, Feb. 1923, p. 210.

Further information is available on the characteristics of the neon glow lamp.[65] These seem to vary with the type of construction, character of the electrodes, distances between them, etc. The voltampere characteristics and spectra have been worked out for two types designed for direct current, one with a star shaped, the other with a conical spiral electrode. Similar experiments have been made on a lamp with the conical spiral electrodes designed for alternating current.

For use as a source of monochromatic radiation for high intensities[66] a quartz sodium-potassium vapor arc lamp has been found satisfactory. It is made by joining two quartz spherical bulbs about 3 cm. in diameter with a short length of quartz tubing 3 mm. bore, each bulb having a long neck attached which carries the electrode wire, an iron rod 4 mm. in diameter. The liquid alloy of sodium-potassium (two parts by weight of sodium and one of potassium) is run into one bulb and both are then exhausted. On passing an electrical discharge through the tubes with the alloy as cathode, the oxide on the surface disintegrates and the surface becomes clean. The alloy can then be made to flow into the other bulb. Using direct current, the lamp works on a minimum applied voltage of 30, although after the arc is struck, which is accomplished by tilting, the fall of potential is only 10 volts with a current of 1.5 amperes. The current should be kept below 1.5 amperes to prevent browning. The lamp does not require continuous pumping while it is working as the alloy absorbs all gasses, particularly nitrogen and hydrogen, while the current is passing. The potassium lines are found to be very faint compared to the sodium lines. A sodium vapor tube having a nickel disk anode 2.5 cm. in diameter and 8 cm. from a tungsten filament 0.038 cm. in diameter, in a 18 cm. pyrex bulb was found to have properties shown in the following table:[67]

| volts | 10 | 14 | 19 | 30 | 100 | 200 |
|---|---|---|---|---|---|---|
| Discharge: | | | | | | |
| amperes | 0.081 | 0.223 | 0.525 | 0.810 | 0.475 | 0.510 |
| Candlepower of glow | 5.1 | 27.2 | 115 | 201.5 | 163.5 | 269.5 |
| Watts/cp. of glow | 0.16 | 0.12 | 0.09 | 0.12 | 0.29 | 0.38 |

[65]Electrician, Dec. 1, 1922, p. 626; Jan. 5, 1923, p. 4.

[66]Phil. Mag., Nov., 1922, p. 944.

[67]Physical Review, Feb. 1923, p. 209.

In gas-filled electric discharge tubes in which an electric discharge is started by supplying current to the electrodes,[68] the starting potential is reduced by combining magnesium or beryllium or their alloys with the metal, e.g. iron or aluminum, forming the electrodes. Thus magnesium or beryllium may be mechanically applied to the electrodes, and material disintegrated from the electrodes by the discharge is prevented from forming a desposit upon the walls of the discharge tube by suitably shaping the electrodes, e.g., by partly surrounding the auxiliary metal or alloy by the electrodes.

## LAMPS FOR PROJECTION PURPOSES

As in the case of other light sources, developments in this class have been more in the direction of minor improvements and increased information as the result of experimental work.

### *Hand Lamps*

The focusing type of hand flashlights has been amplified[69] by providing one end with a bull's eye or outer convex general service lens giving a diffused light over a wide radius and the other end with the spotlight obtained by the focusing reflector and lens. The two lights may be operated independently or both at the same time. Hand lamps are now used for so many purposes[70] that it is difficult to formulate tests which will be sufficiently general to cover all requirements. However, some interesting information was obtained from experiments on lights made by eleven manufacturers. Each lamp was tested with its own battery and lighted for 35 seconds four times an hour, first for eight hours a day, then for twenty-four hours a day, to determine life. The main conclusions were: except in the case of intermittent use, long two or three cell flashlights should be used as the greater life more than compensates for the increased cost; large diameter lenses and reflectors should be avoided except possibly for illumination at a considerable distance; concial reflectors usually give a better distribution than parabolic.

[68] Jour. of Soc. Chem. Ind., Oct. 31, 1922.
[69] Elec. Merch., June 1923, p. 3445.
[70] Elec. Jour., Apr. 1922, p. 150, N.P.R.

A small hand lamp[71] has been brought out in France devised especially for the reading of graduations on scales such as those on optical instruments. It employs a flashlight bulb operating on a dry battery, the light being diffused by a ground glass and in turn reflected from a mica sheet placed at an angle of 45° to the glass plate.

A hand lamp of the general miners' class[72] had been approved by Lloyd's for ships carrying oil having a flashing point of less than 150°; for vessels holding a passenger certificate and using oil fuel; and for employment in petrol tank steamers. The outer case is made of a special aluminum alloy and has a locking device to prevent unauthorized opening of the lamp. The accumulater case is of steel and an alkaline electrolyte is employed which is said to be absolutely unspillable. The continuous lighting capacity is about ten hours.

*Automobiles*

Additional lights are finding their place in the equipment of the latest models in automobiles. Among these may be mentioned the "courtesy"[73] light which silhouettes the arm of the driver when it is extended to signal cars in the rear; the side-door light which illuminates the step when the door is opened; the "backing" light, convenient when going from the garage to the street or when turning on a poorly lighted street.

Recognition of one of the fundamental principles of illuminating engineering[74] is seen in a headlight controller which dims the light gradually instead of making the abrupt change which frequently causes difficulty in seeing on the part of oncoming drivers. The device is operated from the steering wheel by touching a lever on the steering post. Directive action in automobile headlights[75] has in the great majority of cases been accomplished by means of glass lenses with modified surfaces backed by smooth reflectors of the parabolic type but results can be obtained by properly modifying the surface of the reflector itself and this idea is incorporated in a headlight which spreads the beam laterally by

[71] Rev. Gen. de l'Elec., Apr. 21, 1923, 130D.
[72] Elec., Sept. 1, 1922, p. 248.
[73] Elec. Merch., Apr. 1923, p. 3252.
[74] Pop. Mech., Dec. 1922, p. 879.
[75] Jour. of A.I.E.E., July, 1923, p. 754.

means of vertical flutes in the mirror surface, the latter having a hyperbolic rather than a parabolic contour which gives a slightly increased beam depth.

Another departure from the usual type is to be found in a head light which produces two distinct fields of illumination,[76] one of high intensity for distant observation and the other of moderate intensity for side and fore-field illumination. This is accomplished by the combination of a 6 inch paraboloid reflector with an oblique reflecting projector, all the useful light being projected to a vertical slit 0.5 inch in width and 4 inches long and remaining below a horizontal plane 42 inches above the ground. Additional side and fore-field illumination is provided by an independent small side lamp integral with the housing which can also be used as a parking lamp.

A modification of the usual auto tail light is a unit which carries two lamps,[77] a green one which is lighted continuously except when the clutch is thrown out or the brake applied, when it is extinguished and a red lamp lighted. When the car is at a standstill, the red light serves for parking purposes. Two arrows show red to indicate whether the car is going to turn to the right or to the left.

In cooperation with various state authorities,[78] the Bureau of Standards has been carrying on experiments to determine the proper illumination of auto license plates and their visibility under different conditions of illumination. This work has not yet been completed.

An anti-dazzle light bill has been prepared for introduction[79] in the British Parliament. One of the provisions of this bill is that where the range of lamps exceeds 150 feet, a beam must be used which falls below the vision of drivers of other vehicles and of approaching pedestrians.

A special headlight has been developed for mine locomotives.[80] The main body of the lamp has been shaped so as to ward off blows caused by falling coal, is mounted on a sub-base with a three-point suspension and made dust-proof and moisture-proof. Arrangements for hand-focusing are provided.

[76] Jour. of Soc. of Automot. Eng., Jan. 1923, p. 3.
[77] Pop. Mech., Jan. 1923, p. 73.
[78] Jour. of A.I.E.E., Nov. 1922, p. 818.
[79] Elec. Rev., Jan. 12, 1923, p. 66.
[80] Elec. Rec., Jan. 1923, p. 28.

*Signalling*

The number of incandescent lamps used in railway signal work[81] is increasing. The types most commonly used are the 3.5-volt, 0.3-ampere and the 13.5-volt, 0.25-ampere. Through track relays, the lamps light when a train is approaching and are extinguished after it has passed. In this way, batteries are conserved. The use of "sun-valves" has also been introduced. These valves automatically turn the current on and off with the approach and cessation of darkness. Similar applications are being made in the small range-lights and buoy-lights of the lighthouse service.

Automobile traffic has so enormously increased the duties of traffic officers that various devices have been developed from time to time to make their work more effective.[82] One of the latest is a signal lamp the size of a watch which lies in the palm of the hand and is supported by a strap at the wrist. It receives current from a small pocket storage battery weighing only twelve ounces, the connecting wires passing through the sleeve of the coat. The lamp is automatically lighted or extinguished by the raising or lowering of the arm. The life of the battery is claimed to be five years. An innovation in street signalling devices[83] has a bell which automatically rings when the signal operates to show a change in the traffic direction, thus giving an audible as well as a visible notice. The apparatus is about 7.5 feet high and displays a red or a green light at night and the usual stop and go signs by day. The controls are such that the automatic feature may be switched off at will to meet any emergency conditions.

A combined signal and aerodrome portable landing lighthouse[84] has been developed in France. It sheds light through 180° within a radius of nearly a half mile and the light is cut off at so low an altitude that, it is stated, an airman coming to ground would not see the source until his head was on the level with the lamp. The main lens is composed of twenty-one dioptric elements and is enclosed in a metal lantern carried by three adjustable bearings on a four-wheeled truck. The light source is a D. C. arc taking 130 amperes at 60 volts, the carbons being arranged for either automatic or hand feed. In order to make it visible to airmen flying at

[81] Elec. Rec., Jan. 1923, p. 38.
[82] Elec. Merch., July 1923, p. 3493.
[83] Illus. World, Jan. 1923, p. 743.
[84] Elec. Times, Sept. 21, 1922, p. 246.

high altitudes, the top of the lantern carries a fourth order lens (250 mm. focal distance) built up of six dioptric elements and subtending 360°. At the center of this lens is fitted, in an adjustable carrier to permit exact focusing, a 500-watt incandescent lamp wired to flash synchronously with the main beam. The top of this upper lens is closed by a ventilating glass dome. The light of the main beam is said to be visible to the naked eye at a distance of 60 miles. The light from the upper beam is visible under the same conditions at all flying heights as soon as the upper limit of the main beam has been passed.

International regulations covering ships' navigation lights[85] were prescribed in 1910 when it was provided that the starboard green light and the port red light should be visible at a distance of at least two sea miles. No rules were given as to the candlepower of the lights and quality of the colored glass to insure this visibility. This has been remedied as the result of a test conducted in England from which it was deduced that the candlepower at the source should be not less than 12, and 60-watt or preferably 100-watt lamps were recommended. It was found that in practice 85 per cent to 90 per cent of the light was absorbed by approved colored screens.

*Miners Lamps*

Doubts as to the effectiveness of contact breakers[86] in miners' lamps when the glass is broken led the Bureau of Mines to carry out a number of tests. The first consisted of ten 0.65-ampere, 2-volt lamps with the glass bulb removed. The filament was surrounded by an explosive mixture and energized by a 2-volt battery. The second test used the same number and type of lamps but smashed the bulbs after the filaments were lighted. The third test was the same as the first but used a different surrounding explosive gas. The fourth test was made with only one lamp to show how many times the filament could be lighted when exposed to an inflammable gas mixture. The results proved conclusively the necessity of an adequate current interrupting safety device. In fifty-five tests in which the naked filament was exposed either

[85]Elec., July 28, 1922, p. 88.
[86]Elec. Rec., Sept. 1922, p. 170.

at the beginning or after smashing the bulb, fifty-one ignitions occurred, all obtained by normal voltage impressed on the filament.

In British coal mines, the electric safety lamp[87] is replacing the old Davy lamp at the rate of about 22,000 per annum. At the end of 1921 the numbers were approximately 605,500 oil-flame (Davy) and 268,500 electric, the latter number having increased during the past year to nearly 300,000. The experimental work on "pillarless" electric safety lamps[88] which has been conducted by Miners' Lamps Committee during the past two years has reached the stage where the Committee has felt justified in recommending that lamps of this type be accepted for tests. The Secretary of Mines has approved the recommendation. Lamps with a working voltage over 2 must be fitted with a contrivance for interrupting the current automatically in the event of breakage of the well-glass. The object of the "pillarless" lamps is to avoid both the loss of light due to the four or five brass rods or pillars surrounding the glass and the detrimental contrasts and shadows. Six lamps of this type made by different manufacturers were approved shortly after,[89] four of which are required to maintain a light of not less than one candlepower all around a horizontal plane for not less than nine hours and to give a light of not less than 15 candlepower over an arc of 45° in a horizontal plane. The total weight of such lamps must not exceed the specified figures (5.5 to 6.75 pounds). In Australia, coal miners' representatives from the north, south, and west districts of New South Wales[90] have asked for assistance in getting the use of electric lights in the mines. The question is under advisement by the authorities.

*Projection*

A carbon arc for moving picture projection[91] has both carbons horizontal, the crater of the positive carbon facing away from the projector aperture and toward a convex mirror through the center of which passes the metal-coated negative carbon. The rays of light from the positive crater are caught by the reflector and sent back through the projector aperture. No condensing lens is used

[87]Elec. Rev., Apr. 27, 1923, p. 662.
[88]Elec. Times, Aug. 3, 1922, p. 92.
[89]Elec., Dec. 29, 1922, p. 751.
[90]Elec. Rev., Oct. 20, 1922, p. 570.
[91]Mov. Pic. World, June 9, 1923, p. 525.

with this system which is claimed to give an even screen illumination and to be especially efficient for long focal-length projector lenses, since the mirror is located at a good distance from the aperture.

The heat evolved in a searchlight[91a] is considerable and the temperature of the various parts of the apparatus is an important factor in their design. A study of the temperature distribution over the mirror of a 36-inch, 150-ampere, high intensity instrument showed values ranging from 30°C near the outer edge to 85°C near the center. By studying the isothermals, when plotted, shadows were noted and corrections made which, it is expected, will materially increase the life of the mirror.

## STREET LIGHTING

The following statement is quoted from the Report of the Lighting Sales Bureau of the N.E.L.A. for 1922-23[92]: "The year just closed has seen more street lighting improvements made than have been reported in any previous annual period and there is every prospect that the coming year will see still further increases". The trend in the development of ornamental street lighting equipment has been toward higher mounting and larger units. One reason given is the demand for increased illumination due to modern traffic conditions and because the efficiency of the gas-filled tungsten lamp increases rapidly with its size. Installations have been made during the past year involving ornamental standards with mounting heights varying from 16 to 30 feet equipped with lamps in sizes up to 25,000 lumens. Some attention is being given to alleys, always inclined to be dark and frequently the scene of crime.

The Report of the Street Lighting Committee of the American Society for Municipal Improvements[93] contains a table of "street lighting practice" in which the recommendations for main business thoroughfares in cities of 100,000 population or larger are 10,000 to 50,000 lumens per post with mounting heights 14 to 25 feet and spacing 80 to 150 feet. For similar streets and cities from 20,000 to 100,000 population, 10,000 to 25,000 lumens per post are pro-

[91a] Gen. Elec. Rev., Aug. 1922, p. 498.
[92] Report of Lighting Sales Bureau, N.E.L.A., June 1923.
[93] Jour. of A.I.E.E., Feb. 1923, p. 178.

posed. This indicates the keen interest of municipal authorities in the desirability of improved street lighting. Before the war the Bureau of Standards undertook a comprehensive study of street-lighting service of all types,—gas, electric and other special classes.[94] It was to include the problems of design of street-lighting systems from the illumination standpoint; the distribution of gas and electricity for street-lighting purposes; methods of operating and maintenance; and the technical and engineering features of contracts. This study, which was interrupted by the war, has been actively resumed.

The following is quoted as part of a discussion at a meeting of the local branch of the Psychological Corporation[95] at Washington: "Street lighting must be based on common sense, but no good sense ignores scientific facts. Modern street-lighting makes a pretty effect, but it is inefficient in these days of congested fast traffic and high taxes. It would pay any city to have its lighting arrangements planned by a specialist—an illuminating engineer in consultation with artists and the local lighting companies". The last sentence contains a doctrine which has been preached by this society for a good many years.

The installation of additional gas street lamps was made in eleven cities in December of last year[96] and in thirty-five cities in January and May of this year.[97]

A legal measure which promises to facilitate improved highway lighting has been passed in New York State.[98] It allows the counties of the state to appropriate money for the illumination of highways. The importance of such lighting is becoming more seriously recognized in all parts of the country.

Information has been received from engineers in a number of the larger cities and incorporated in the following descriptions of specific installations.

*Western Coast*

Seattle has just completed a new installation of sixty-four single light units of the 6,000-lumen, 20-ampere incandescent

[94] Elec. World, Apr. 7, 1923, p. 806.
[95] Science-News-Letter, March 10, 1923.
[96] Am. Gas Jour., Dec. 9, 1922, p. 667.
[97] Gas Age-Rec., Jan. 20, 1923, p. 98; Am. Gas Jour., July 14, 1923, p. 43.
[98] Jour. of A.I.E.E., Dec. 1922, p. 1033.

lamp type mounted on high poles designed by the city. These poles have replaced center span units. In San Francisco, changing over from gas to electric lights has been slowly progressing. There is at present on foot a movement to put some ornamental lamps in "Chinatown", these being of a character that will convey by their very outline the oriental idea. The Chinese are not at all adverse to spending a considerable sum of money in order to secure the installation of this lighting system which will be in the nature of "white way" lighting.

Altadena, a suburb of Pasadena, Calif., is made up mainly of country estates.[99] The problem of street-lighting was actually one of high-way lighting and was solved by the use of refractor units suspended by a central span arrangement with inconspicuous wires. The light height is 28 feet above the road and the spacing 540 feet. Two hundred seventy units have been installed in a lighting district covering about four square miles.

Attention is being given to improving the lighting in the outlying districts and those business streets not already included in the present ornamental lighting area of Los Angeles.[100] Pendant units will be employed having 20-ampere series incandescent filament lamps in closed-bowl refractors consisting of two pieces of pressed crystal glass nested one within the other.

*Middle West*

Denver celebrated the completion of its ornamental street llighting[101] by a carnival last December. A new city ordinance[102] has provided for the lighting of alleys and the police claim this is responsible for the gradual decrease in the number of burglaries and hold-ups in the downtown district, as well as materially protecting the policemen on their beats.

Mandan, N. D., a city of only about 4400 inhabitants, has installed[103] an ornamental system of 447 standards or one to each ten persons. One-hundred-candlepower lamps in urn-shaped globes 10.5 feet from the ground are used in the residential sections and 12-foot standards with 250-cp. lamps in the business district.

[99] Jour. of Elec. and W.I., Jan. 15, 1923, p. 55.
[100] Public Works, Apr. 1923, p. 135.
[101] Jour. of Elec. and W.I., Jan. 15, 1923, p. 68.
[102] Elec. World, June 9, 1923, p. 1376.
[103] Elec. World, Oct. 14, 1922, p. 829.

About 9.5 miles of streets are lighted. A residential boulevard in St. Paul[104] is lighted by a system consisting of 400 ornamental refractor lanterns on standards 120 feet apart and carrying 400-cp. tungsten incandescent lamps. In order to show the advantages and possibilities of improved lighting, a one mile "sample" installation of twenty 400-cp. lamps has been placed[105] on part of a twelve mile rural "white way" between Kenosha and Racine, Wis. If satisfactory, the entire district will be so lighted. An ornamental lighting system in the city parks of Green Bay, Wis.,[106] has been made possible by the response to a suggestion by the City Park Commissioner that fifty people donate $100 each to the city to be used for lamp posts in the parks. At least fifty 10-foot standards with octagonal lanterns will be installed.

The outstanding development in street illumination in the city of Milwaukee in the year 1922 was the entire elimination of electric arc lamps and of gas and gasoline lamps. The city is now lighted entirely by series incandescent electric lamps of various sizes. There are now in service approximately

| | |
|---|---|
| 3550 – | 100 cp. lamps |
| 1970 – | 250 cp. lamps |
| 2750 – | 400 cp. lamps |
| 1360 – | 600 cp. lamps |
| 530 – | 1000 cp. lamps |

Attention should be called to the lighting of Kansas City, Mo.,[107] which was referred to in the May issue of the Transactions. Appropriation has been made for the rejuvenation of the street lighting in St. Louis, Mo.[108] Approximately 23,000 gas street lamps will be replaced by about 50,000 electric lights. Some experimentation is to be carried out to determine by actual use what type of lamp and reflector gives the most satisfactory lighting. One unit to be tried out has a special refractor lens placed on the sidewalk side of the lamp to limit the area of illumination, light the sidewalk without throwing light into the houses and illuminate the area of the street well over to the other side. Maplewood, a

[104]Central Station, Jan. 1923, p. 208.
[105]Elec. Rec., Jan. 1923, p. 9.
[106]Ibid, April, 1923, p. 252.
[107]Elec. World, Feb. 10, 1923, p. 321.
[108]Ibid, June 23, 1923, p. 1491.

suburb of St. Louis,[109] has inaugurated a "white way" consisting of one hundred and fifty 250-cp. series incandescent filament lamps mounted on ornamental iron standards spaced 50 to 80 feet apart.

Oak Cliff, a suburb of Dallas, Texas,[110] is putting in a "white way" with 31 standards each carrying a 10,000-lumen lamp. El Paso's business district is being equipped with an ornamental lighting system, the standards being furnished by business men.

*Central States*

Part of a plan for relighting Lansing, Mich.,[111] has been completed. It is claimed that this is the first case in the United States where the street lighting system was designed on the basis of architectural uniformity. On the main business streets, two-light standards will be used with 10,000-lumen lamps placed 20 feet from the ground. Secondary business streets will have single light standards 15 feet high with the same luminous flux output while boulevards will have 13 foot standards and 4,000-lumen lamps. For the minor residential districts, the 2500-lumen size will be employed with a mounting height of 11 feet 6 inches.

A system at Lima, Ohio,[112] which was referred to in the 1922 Report has been completed and details are now available. It is said to be noteworthy as a tendency on the part of municipalities to treat ornamental lighting as a part of a scheme to beautify the city as a whole. Another interesting feature is the graduation of candlepower, mounting height and spacing in accordance with the requirements of the individual streets. In the public square, the posts are 15 feet high with 1,000-cp. lamps and special refractors which throw the light toward the center of the square. On the main business street, they are 13 feet 3 inches high and carry 400-cp lamps. On the minor business thoroughfares and in the residential sections, the posts are 1 foot lower and carry 250-cp. lamps. Down town the spacing is 50 feet but throughout the balance of the system, 100 feet is the standard distance. Twelve hundred forty five units are involved, extending over 16.2 miles of streets covering the downtown section and four of the principal residential thor

[109]Elec. World, May 19, 1923, p. 1169.
[110]Elec. Rec., Apr. 1923, p. 251.
[111]Elec. World, Mar. 3, 1923, p. 511.
[112]Public Works, Sept. 1922, p. 150.

oughfares. Newark, Ohio,[113] clamis to be one of the first cities to use the new 25,000-lumen tungsten filament lamps. They are mounted 30 feet above the sidewalks in special bowl refractor pendants arranged to give a maximum illumination at 15° below the horizontal.

The advantage of good street lighting in advertising a city which is in the path of through auto traffic has been recognized by Freemont, Ohio.[114] In redesigning the lighting system, the following ideas were incorporated: a closer spacing of lighting units on all residential streets to eliminate dark shadows and create an atmosphere of safety; a bright "white way" in the central business district which will attract trade and dispel an impression of deadness in this district after dark; adequate lighting for the principal thoroughfare from city limit to city limit. The old lighting consisted of 328 lamps mostly 4-ampere magnetite arc. The new series has 602 incandescent filament lamps ranging in size from 100 to 600 cp. The latter size is used in the main street on 13.5 foot pressed steel standards spaced 80 feet apart on each side of the street and on the main through highway at a mounting height of 20 feet and at distances to give one lamp for 150 feet of street. Rippled globes with refractors are used for the glassware. For the less traversed streets 400-cp., 15-ampere lamps are employed in rippled globe, dome refractor units on mast arms at heights 20 to 25 feet above the ground. On residential streets 250-cp. lamps are suspended from mast arms while 100-cp. lamps with radial wave reflectors are used in alleys and outlying districts.

In Cleveland, Ohio, increases in lighting equipment have been as follows: eleven 4-ampere magnetite arcs, one hundred sixty-four 600-cp., 20-ampere incandescent filament lamps and twenty-eight 1,000-cp. "white way" lamps. A new "white way" on East 105th Street has been added to that already established on Euclid Avenue. It consists of sixty-eight 1500-cp. units, fifty-nine 1,000-cp. units and nine of the 600-cp. size.

*Eastern Cities*

Buffalo is carrying out the plan developed sometime ago.[115] Two hundred inverted magnetite arcs have been installed on

[113]Report of Lighting Sales Bureau, N.E.L.A., June, 1923, p. 27.
[114]Elec. World, July 14, 1923, p. 73.

Niagara Street and 800 more will be placed this year in the business district. Syracuse, New York, has designed a thoroughly up to date street lighting system.[116] Four types of lighting are called for, involving business streets, main and secondary thoroughfares, and residential districts. Seven hundred five-lamp ornamental poles and two thousand 4-ampere luminous arcs on overhead lines will be abandoned. The new lights will be supplied from underground circuits. The new plan provides for cast iron posts with two 6.6-ampere inverted luminous arc lamps with 100-foot spacing and 18.5 feet mounting height. On side streets one-light posts alternate with a mounting height of 14.5 feet. For main thoroughfares, cast iron posts will be used carrying 400-cp. 7.5 ampere series incandescent lamps in large lanterns, the posts being 125 to 200 feet apart and with a light source 12.5 feet from the ground, and similar equipment and spacing for residence sections.

There has been no increase in the number of incandescent lamps in Philadelphia since June 1922. However, at scattered locations throughout the city arc lamps have been erected to the number of 406. Arrangements are being made for a comprehensive scheme of lighting by high candlepower incandescent lamps, experiments for which have been going on for sometime, to be installed for ten miles on Broad Street, In the business district of Boston,[117] 76 magnetite arc lamps mounted 14.5 feet above the sidewalk on posts of the boulevard type have been installed. The lamps are placed opposite each other with 75 to 85 foot spacings.

In New York City at the close of the year 1922, there were 81,731 lamps in service on the streets and in the parks of which 7789 were gas, 12 were naphtha, and 73,930 were electric. This is a decrease of 1223 gas lamps and an increase of 3614 electric lamps from the number in service at the beginning of this year. The total number of lamps installed was 4563 and of this number 1345 were 25-watt or 60-cp. units inclosed in a vermilion colored globe used in connection with the improved fire-alarm signal system and 18 were 25-watt lamps used in connection with the new traffic signal stations. In the latter six lamps are installed in each station, two of which burn continuously during the hours public street

[115]Elec. World, Feb. 24, 1923, p. 473.
[116]Ibid, May 26, 1923, p. 1232.
[117]Elec. World Aug. 5, 1922, p. 294.

amps are required to burn and four burn intermittently during he same hours. In the spring of this year, the city officially pened its mammouth boardwalk along the beach at Coney Island, ighted by 158 pairs of 200-watt incandescent filament lamps of vhich one lamp on each of 79 posts burns all night and the others urn from official lighting time to 1:00 a. m.

A new and modern system has been installed in Charlotte, N. C.[118] Gas-filled incandescent lamps in refractor globes constitute the light sources.

*Canada*

Comparing street lighting on the basis of candlepower per 100 f population,[119] the following figures show Canadian practice:

| | |
|---|---|
| Pembroke | 1758 cp. per 100 of population |
| Hamilton | 1000 " " " " " |
| Toronto | 920 " " " " " |
| Chatham | 900 " " " " " |
| Sarnia | 770 " " " " " |
| London | 700 " " " " " |

Pembroke is lighted by 230 lamps, 50 of 1000-cp., 103 of 600-cp. nd 17 of 100-cp.

*Great Britain*

Practice in England is indicated by the following table[120] suggested in a report of a joint committee and referred to in a discussion before the English Illuminating Engineering Society.

| Character | Minimum Illumination in Foot-Candles |
|---|---|
| Important Streets | 0.06 to 0.1 |
| Good Class District | 0.04 to 0.06 |
| Average London District | 0.025 to 0.04 |
| Residential London District | 0.01 to 0.025 |
| Poorer Class District | 0.01 and below |

n another discussion on street lighting before that Society,[121] it was rought out that in London the height of centrally suspended amps averages 25 to 27 feet with a spacing of 100 feet. Special ttings and columns were designed for the lighting of St. James' Park New Road, London.[122] The system involves ten lamps,

[118]Elec. Rec., Dec. 1922, p. 390.
[119]Elec. News, June 1, 1923, p. 67.
[120]Ill. Eng., Jan. 1923, p. 6.
[121]Ibid, p. 1.
[122]Ibid, Sept. 1922, p. 257.

each containing a cluster of 16 super-heated burners providing ar intensity of approximately 1000-cp. and consuming about 2.25 cu ft. of gas each. The columns are approximately 180 feet apar and the height from the ground to the mantle is 22 feet. Lightin and extinguishing is handled from a tap at the base of the colum controlling a pilot light. Reference should be made to a pape presented before the Public Works, Roads and Transport Con gress in England[123] by the distributing department of a London ga company. In regard to research the paper says: "The endeavo ....to achieve a satisfactory system of public lighting under thes conditions resolves itself into: (1) the experimental determinatio and specification of a burner suitable for use under the extreme con ditions met with in its subsequent use in the streets; (2) the as sembling of component parts for the bulk manufacture of suc standardized burners; (3) the verification from time to time o the duty rendered by burners supplied in bulk, and (4) furthe experimental work tending to enhance the efficiency of the ap pliance". Data and curves are included showing results of test made by the company on street lighting equipment.

Birmingham has 22,000 public gas lamps.[124] These include number of high pressure units, some centrally hung, some o 30 foot columns on island junctions in main thoroughfares. O certain islands, three low pressure lamps are installed, the highes and middle ones being fitted with ruby glass and used as "safet first" traffic regulators. In testing burners for city lighting, it i required that they must not pass 0.05 cu. ft. of gas less or mor than a predetermined amount. Mantles have to pass certain gauge

Having decided to continue gas lighting, Leamington, Eng land,[125] has adopted new square lanterns with inverted fitting and automatic lighting and extinguishing. In Glasgow,[126] lighte mainly by flaming arcs, the mounting height is 20 to 25 feet an the spacing 120 to 150 feet. In a section of one of the narro streets about 40 feet broad lighted by one 350-watt gas-fille tungsten lamp in a directive fitting 27.5 feet above the groun values of horizontal illumination 1 meter above the road wer found to be as follows: under lamp on center line, 0.95 fc.; 30 fe

[123]Gas-Age-Rec., July 14, 1923, p. 37.
[124]Ill Eng., Jan. 1923, p. 24; Gas Jour., Jan. 10, 1923, p. 85.
[125]Gas Jour., Aug. 30, 1922, p. 481.
[126]Ill. Eng., Jan. 1923, p. 1.

long the street, 0.41; 60 feet further, 0.44; 120 feet further, 0,067. In another stretch of street with similar fittings 150 feet apart, here was a maximum of 0.52 fc. and midway between the lamps 0.107 fc. The total number of lamps in Edinburgh[127] at the end of he fiscal year, May 1922, was 1690. Modified lighting as compared to pre-war times has been accomplished by reducing the candlepower instead of limiting the number of lamps.

### OTHER EXTERIOR ILLUMINATION

Developments in exterior illumination have been mainly in he direction of sign or display lighting and the problems connected with transportation in one form or another. The increased se of airplanes for commercial purposes has necessitated special onsideration of the lighting requirements of this type of navigation.

The Committee on Practical Illumination Questions of the German I. E. S. has recommended the following for illumination values[128] in general exterior lighting such as that of open parkways, factory yards, railroad yards and docks:

| Location | Mean Illumination | Minimum Illumination |
|---|---|---|
| Railroad trackyards | 0.2–0.5 | 0.1–0.3 |
| Same near factory sidings | 0.5–1.5 | 0.2–0.5 |
| Streets and Parks | | |
| Light traffic | 0.5–1.5 | 0.05–0.3 |
| Heavy traffic | 1.5–5 | 0.3–1 |
| In front of railroad stations | 5 –10 | 1 –2 |

These values are for horizontal illumination at a height of 1 meter above the ground.

*Pageants*

The Tercentennial Exposition in Gothenburg, Sweden, offered another opportunity to employ the expressive possibilities of lighting.[129] As a result the artistic lines and the architectural beauty of the buildings are said to be more evident at night than in daytime. At the portal of the Sports Hall advantage has been taken of a small lake to produce a beautiful effect, as it mirrors in rainbow streams the vari-colored lights outlining the building

[127]Elec., Sept. 8, 1922, p. 266.
[128]L. u. L., Apr. 26, 1923, p. 207.
[129]Pop. Mech., Aug. 1923, p. 246.

and the adjoining promenade. In another building lights placed in geometrical design behind towering columns give it the appearance of a glowing jewel guarded by pillars of steel and surmounted by a crown of fire.

One of the attractions of the Rocky Mountain Electric Exposition[130] held at Salt Lake City was a huge "Regional Arch" in colored lights and jewels. A curtain containing some 15,000 "jewels" and suspended about 25 feet above the ground carried at each end a rosette with three shields containing the official emblems of the six Rocky Mountain states. Each rosette carried a lightning burst and together with the curtain were illuminated by two hidden batteries of ten 18 inch arc searchlights provided with colored filters.

Again this year the Capitol City[131] was elaborately lighted, the occasion being the Shriners' Convention. At night Pennsylvania Avenue from the Capitol to the Treasury Building presented a veritable ceiling of lights—red, green, yellow and white,—divided at intervals by curtains of light extending below the main canopy. Prominent buildings were floodlighted and Lafayette Square was brilliantly illuminated as the Court of Honor.

Reference should be made to the spectacular lighting of the Centennial Exposition at Rio de Janiero, which was described in the October 1922 issue of the Transactions.

*Buildings*

Display lighting by neon tubes[132] has been employed in Paris for some years. What is said to be the first example of outlined lighting by this illuminant in England is that of the tower of a building in London. The glass tubes are 30 mm. in diameter and bent to the shape of the arches and other main lines of the structure. When lighted they appear as broad bands of orange color but when extinguished they are hardly perceptible. The tubes are connected in a series of 13 distinct groups, each with its own transformer.

The problem of providing light for a one-day-a-week outdoor market is taken care of in an English town by a temporary wiring

[130]Southw. Elec., Aug. 1922, p. 23.
[131]Elec. World, June 23, 1923, p. 1490.
[132]Elec. Rev., May 11, 1923, p. 746.

lay-out,[133] the erection and dismantling of which requires the labor of one man for one day. Each of forty to fifty stalls are supplied with one 50-watt lamp, the lights being on until 9 p. m.

A novel instance of protective lighting[134] is found in a Detroit building in which the exterior spaces between the supporting columns are strongly illuminated by 200-watt lamps in reflectors set in the building 24 feet above the sidewalk. In this way the dark shadows of the columns which might conceal loiterers and cause apprehension in the minds of passing pedestrians are obliterated.

*Signs*

Not a little general street illumination in cities[135] comes from illuminated or self-luminous signs. It is reported that while less than 10 per cent of city showings are illuminated, it is expected that this number will be increased to 20 per cent before the end of 1923. Some statistical data have been obtained [136] on the number and size of signs in eight cities ranging from 10,000 to 350,000 in population. The data show an average of one sign and 202 sockets for every 735 persons. Practice in the number of signs and of sockets was found to vary widely in the different cities. The situation in New York where another survey of this kind was made, was referred to in the April 1923 number of the Transactions.

Again the claim to be the largest electric sign in the world has appeared.[137] The letters of this sign are 56.5 feet high, the vertical parts being 12 feet wide and the horizontal, 10 feet wide. The outside dimensions of the structure are 153 feet by 75 feet and the weight is 100 tons. It is said to be legible to the naked eye at 8 miles and visible at a distance of 30 miles.

The slow progress of sign lighting in England[138] is attributed to antiquated restrictive legislation. Piccadilly Circus, undoubtedly the most conspicuous place in London, is not as yet comparable to Broadway in its display lighting. One factor which has a great effect on the lighting situation is that the Crown, which owns

[133]Elec. Times, Dec. 21, 1922. p. 586.
[134]Pop. Mech., Dec. 1922, p. 848.
[135]Signs of the Times, Jan. 1923, p. 20.
[136]Jour. of A.I.E.E., Dec. 1922, p. 1033.
[137]Signs of the Times, Mar. 1923, p. 64.
[138]Signs of the Times, Mar. 1923, p. 58.

a large amount of property in the shopping district, will not allow any illuminated signs on buildings erected on these sites, and has refused to alter existing laws.

*Aerial*

What is reported to be the first aerial lighthouse in this country[139] has been put in operation at College Point, Long Island, under the supervision of the United States Lighthouse Service. The source is a 14-inch navy type searchlight throwing its beams upward at an angle between 45° and 60°. The cross country service to be inaugurated by the Post Office Department[140] will necessitate a string of beacons stretching across the country. Lighted emergency fields will form a continuously lighted highway from Chicago to San Francisco, the part of the route covered at night. The most powerful lights will be located at each of the regular flying fields,—Chicago, Iowa City, Omaha, North Platte, and Cheyenne. Each will be of 600,000,000 cp. and will swing slowly around on a tower mounting, being visible 50 miles away. The intermediate lights will also be on towers and have a visibility range of 30 miles. As a final safeguard in cases of compulsory low flying, flashing traffic lights directed upward will be located every three miles. The huge field at Chicago will be outlined with lights spaced 200 feet apart. In one corner a large well-lighted arrow pivoted like a weather cock will give the pilot wind directions. On top of the hangars a floodlight will throw a pattern of light on the field. This is placed high enough to prevent glare in the eyes of the pilot.

An interesting mathematical study[141] has been made of the probability of detecting an airplane by a searchlight beam with a range of 10 km. and a beam solid angle equal to 2°. A probability of 600 to 1 is deduced that the airplane will not be illuminated. At 1 km. the probability is reduced to 3600 to 1. If the solid angle of the beam is reduced to 1°, the probabilities for the two ranges are 9200 to 1 and 22,900 to 1 respectively. Taking into account the effects of duration of illumination, of beams of different solid angles and different intensities and also the influence of the move-

[139]Popular Mech., July 1923, p. 58.
[140]C. R., Sept. 18, 1922, p. 466.
[141]C. R., Sept., 18, 1922, p. 466.

nent of the beam in sweeping the sky, it was found, as would be xpected, that it is to the interest of the aviator to fly as high as ossible. In a typical case the probability of his escaping de- ection is increased in the ratio of 100 to 14 when the flying height s increased from 1,000 m to 5,000 m.

*Bridges*

The lighting of the new memorial bridge at Springfield, Massa- husetts,[142] combines architectural fitness and beauty with good ngineering practice. Four central towers 80 feet high capped vith sectional duffused globes 6 inches in diameter, each containing our 500-watt incandescent filament lamps, provide general lumination. The sides of the bridge are equipped with 50– ampere nverted magnetite arcs on posts 18 feet high. Special attention as been given to the planning of the lighting system[143] of the new ridge over the Mohawk River at Schenectady. Concrete obelisks vill form the support for bronze lamp holders and brackets. These obelisks will rise to a height of 21 feet above the parapet f the bridge and will be spaced at 100 feet intervals. The light nits, 1500–cp. 6.6– ampere incandescent filament lamps in eight- anel globes, will be 17 feet above the roadway. Another example f bridge lighting,[144] although in this case only temporary, was hat during the celebration of the opening of the new Broadway Bridge at Little Rock, Ark. Four batteries, each consisting of wo 1,000-cp. and three 5 00-cp. units, were employed to illuminate he structure and placed about 100 feet away on both sides of the ridge and the river. To bring out the center span, additional loodlights were installed about 250 feet away.

*Transportation*

The importance of good lighting in railway yards, shops and oundhouses was emphasized in a discussion[145] at the January neeting of the Society of Terminal Engineers. Yard lighting is rimarily space lighting with the following problems injected; namely, the presence of deteriorating gases, movable cars causing

[142]Elec. World, Feb. 17, 1923, p. 378; Mar. 10, 1923, p. 578.
[143]Elec. Record, Feb. 1923, p. 116.
[144]Elec. World, April 7, 1923, p. 825.
[145]Railway Elec. Eng., Jan. 1923, pp. 2, 17.

shadows, lack of clearance between tracks to place poles, the prevention of glare that will interfere with the operation of trains through or near the yards and in some cases the presence of overhead propulsion-current wires. One solution has been found in the use of 1,000-watt lamps in silvered glass reflectors of the flood-lighting type. Searchlights of the 400-watt size are also used. It has been felt that while flood lamps are not a "cure all", their use has resulted in a large increase in efficiency, decrease in accidents and a minimum of expense.

To enable passengers to enjoy scenic effects at night, it is planned by a transcontinental system [146]to equip the ends of its observation cars with batteries of powerful searchlights. They will be arranged to cover 160° with sufficient height and depth to illuminate cannons, mountains, rivers and lakes along the right of way. The use of colored screens is also proposed.

The Merchant Shipping Advisory Committee in England[147] has recommended the illumination of lifeboats upon launching. Equipment for this purpose provides two 4-volt lamps mounted in the ends of battens pivoted upon the gunwale of each boat. A battery furnishes current enough to maintain the illumination for 24 hours. The lamps are switched on through the agency of a float which acts as soon as the boat touches the water. The arms holding the lamps are adjustable to permit a larger or smaller area of illumination.

### INTERIOR ILLUMINATION

What is believed to be the earliest recorded example of the "indirect" system of lighting is credited to Queen Victoria.[148] About 1890 at her suggestion, the Durbar Room at Osborne was illuminated entirely by "deflected" light, not a lamp or fitting or any source of light being noticeable. One of the most novel uses for artificial daylight is that of providing illumination[149] for the examination of fabrics and articles found in the tomb of King Tutankhamen at Luxor, the object being to avoid the necessity of bringing the materials out into the open air and sunlight in order to distinguish the shades and colorings.

[146]Pop. Mech., Oct. 1922, p. 514.
[147]Elec. Rev., May 25, 1923, p. 831.
[148]Elec. Rev., Sept. 8, 1922, p. 346.
[149]Pop. Mech., Aug. 1923, p. 201.

It has been computed[150] that there are four times as many artificial lighting hours in winter as in summer. One and a half hours cover the use of light in the average residence in June while six and a half hours is the average time for December. Occasionally during the year, tables of recommended foot-candle values have been published for various industries[151] ranging from canning factories and packing houses to woodworking plants as well as for all kinds of small stores. In general, they show higher values than heretofore. Additional data on the effect of increased illumination on output have been obtained[152] including the results of the post office tests referred to later. In nine different types of industrial work an average increase from 2.3 fc. to 11.2 fc. gave an average production increase of 15.5 per cent. A test in a Lancashire coal mine[153] on behalf of the Institute of Industrial Psychology, England, showed over 14.5 per cent increase in output as the result of using six times the ordinary illumination as given by miners' standard lamps. This was in spite of the very considerable increased weight of the higher candlepower lamps.

It is reported[154] that many central stations are adding a lighting expert to their personnel. These engineers are endeavoring to cooperate with architects, consulting engineers and building owners to insure as far as possible the installation of good illumination for lighting systems in large buildings of both the commercial and public type, recommended foot-candle values for which have also been worked out.

*Public Buildings*

Since the largest part of the work done in the postal service involves vision under artificial illumination, it is gratifying to have lighting conditions in post offices made the subject of a government investigation.[155] A discussion of this work was given in the Transactions for March 1923.

The lighting of the new building of the London County Council[156] gives an illustration of present English practice for large

[150]Gas Age-Rec., Jan. 20, 1923, p. 84.
[151]Elec. Rec., Feb. 1923, p. 76 and Apr. 1923, p. 247; Indus. Eng., Nov. 1922, p. 511.
[152]Elec. World, June 30, 1923, p. 1530.
[153]Elec. Rec., May, 1923, p. 315.
[154]Report of Lighting Sales Bureau, N. E. L. A., June 1923, p. 18.
[155]Elec. World, Feb. 24, 1923, p. 470; Mar. 24, 1923, p. 673.
[156]Elec. Times, July 20, 1922, p. 53.

public buildings. In the main council chamber are four bowl fittings 5 feet in diameter and 7 feet tall of bronze supported by bronze chains about 40 feet above the floor levels. In each bowl are ten 300-watt lamps. On the marble staircase six bronze standards 7.5 feet high, carrying 22-inch opal glass globes containing 300-watt lamps, provide a decorative as well as impressive illumination. Bowl ceiling luminairies are used in the gallery surrounding the staircase. The corridors are lighted by small bronze ceiling fittings to the number of about 500. A large bronze lantern lights the terrace entrance hall while cast bronze pendants with 20-inch bowls furnish light for the street entrance hall. In the lobbies to the entrance hall are special bronze ceiling fittings with shallow satin-finished glass dishes, the top reflector with the lamp holder being sunk into the roof.

The Educational Committee of the London County Council has decided [157] to replace, in those elementary school buildings largely used at night, the old upright mantle burners by superheated inverted burners adapted to existing fittings. A type of luminaire will be employed which carries a cluster of small mantles without glassware and equipped with a deep type of enamel shade so as to screen thoroughly the eyes of teachers and pupils from glare.

Canadian practice in hotel lighting[158] may be seen in what is claimed to be the largest hotel in the British Empire. Approximately 5000 lighting units are employed. One-hundred-watt gas-filled incandescent lamps are used in the bedrooms, 25-watt vacuum incandescent lamps in the bathrooms and corridors, and 200-watt lamps in the shops. The glass was especially designed for the hotel.

A new large hotel in this country[159] has over 11,000 lamps. Among the novel features of this installation may be mentioned the use of wrought iron in some of the public rooms. One luminaire in the men's cafe has a full rigged ship of the galleon type in the center of an elaborate wrought iron frame work, which also carries a number of candelabra fittings. Another large wrought-iron luminaire is in the palm or sun room. In the library is a luminaire in the form of a terrestrial globe, while localized lighting is provided by two brackets over the fireplace and by floor and table lamps. In the writing room portables are combined with ceiling

[157]Gas Jour., Oct. 18, 1922, p. 176.
[158]Elec. News, Aug. 1, 1923, p. 43.
[159]Ltg. Fix. & Ltg., July 1923, p. 15.

pieces and localized two-light units over each desk. A six-light luminaire of colonial design is used in private sitting rooms along with table lamps.

Lighting equipment and methods have improved so much in the last twenty years that redecoration of a public building is not complete without a rejuvenation of the lighting system.[160] A case in point is that of a church whose trustees desired to retain the beauty of the original decorations and hence had the new luminaires planned with this point in view. Ten dark bronze pendants were made, each fitted with twenty-eight 25-watt candle-flame tinted lamps. Brackets for the vestibule and balcony were designed to harmonize with the elaborate wooden paneling which is a feature of this church. In changing over from a gas to an electric system an English church[161] used the original ring fittings but suspended from each ring four 100-watt lamps in glass shades. The illumination values were increased from an average of 0.5 fc. with practically no light in the upper sections of the auditorium to more than 1.5 fc. with a range from 0.8 to 3. Two 100-watt pip-frosted lamps on brackets were used to light the chancel and the illumination at the middle of the choir stalls was increased from 0.7 to 7.5 fc. The reredos was lighted with concealed carbon lamps and the lecturn, provided with a specially designed luminaire, showed an illumination of 1 fc. A novel item was the use of two green 40-watt lamps by which the organist gives the time for the choir to whom he is invisible. They are fixed on either side of the chancel arch but out of sight from the nave. Signal lights at the organ were installed so that the organist may be notified of the entrance of the choir in the case of processional hymns.

A prize fighting ring requires a lighting system similar to that of some exhibitions and pageants; i.e., relatively concentrated lighting over a small area.[162] In one case good results were obtained by installing a 1000-watt lamp 14 feet above the center of the ring which was 20 feet square. Eight glass reflector units with 100-watt bowl frosted lamps were mounted on a 14-foot square conduit frame 12 feet high. These lamps were carefully tilted to keep the glare from the eyes of the occupants of the press bench located

[160]Lighting Fixtures & Lighting, Feb. 1923, p. 29.
[161]Elec. Rev., May 4, 1923, p. 700.
[162]Elec. Rec., Mar. 1923, p. 182.

around the ring, and were provided with a piece of glass at the bottom to protect the eyes of the spectators. The illumination was 45 fc.

A new building, erected by the various packing interests of a western city for industrial expositions and live stock shows, has its arena lighted by RLM dome reflectors with 500-watt lamps.[163] They are arranged to be lowered 12 feet from the ceiling when extra high illumination is desired as in judging cattle. Normally they are suspended at the ceiling which is 39 feet high and produce an illumination of 8 fc. In the lowered position 16 fc. are available. At the outer edge of the arena, tests showed 9 fc. The corridors below the seats are lighted by various angle type reflectors equipped with 200-watt lamps mounted on columns and side walls.

*Galleries*

The fading of colored objects in museums is a serious loss in many cases.[164] To ascertain corrective measures, if they exist, a study was made involving exposures on 2515 days during the eight years from 1914 to 1921 on fugitive colors (chiefly synthetic dyes). Maximum fading was caused by direct sunlight and diffused sunlight was found to be more destructive than artificial light. Tinted glasses varied in their protective effect according to their relative power to absorb the violet and blue rays, but most of such glasses were objectionable because they altered the appearance of the objects viewed through them. The best glasses only delayed fading; they did not prevent it. Pigments made with oil fade less rapidly than when made up as water color. It was concluded that artificial light is desirable for museums in order that the fading of objects may be delayed. This subject was referred to in the Transtions for March and July, 1923.

A recent art gallery lighting installation[165] is said to be different from and yet embody the good points of two methods already in use elsewhere, one where the lighting is accomplished from the sides and the other where the illumination simulates actual daylight conditions coming uniformly from overhead. In the case referred to, three rooms have horizontal skylights while that in the fourth is vertical. Above the glass are placed 150- and 200-watt

[163]Elec. Rec., June 1923, p. 383.
[164]Jour. Royal Soc. of Arts, *71*, 1923, p. 144.
[165]Elec. Rec., July 1923, p. 3.

ue bulb lamps in mirrored glass projectors. They direct the beam light on the opposite rather than on the adjacent wall. The sky-ght glass conceals the light sources but does not materially odify the distribution. This general scheme is similar to that of e Cleveland Museum of Art described before the Society some ars ago. The walls of the gallery are neutral in tone, non-glossy d of low reflecting power. There is enough stray light to make e skylight luminous and produce general illumination in the ntral portions of the rooms. Outside of the vertical skylight are aced seven weather-proof type floodlighting projectors with 500-att clear lamps. The light beams are directed against the opposite all, painted a light cream color, from which they are diffused and uminate the rest of the room. The foot-candle values at the .8– and 4-foot levels measured 7.2, 5.2, and 3.1 fc. on one wall d 4.6, 3.2, and 2.2 fc. on the other wall. In the galleries having e horizontal skylights at the same height levels, the foot-candle lues were found to be 3.5, 2.8, and 2.3 fc. Some long narrow lleries are lighted by single rows of totally indirect units.

*heaters*

The three-color indirect system[166] continues to be the dominant ature in the lighting of moving picture theaters. In order to minate eye-strain and make the pictures as clear and sharply sible from the side seats as those directly in front, a movie screen s been constructed[167] with a white surface embossed with a multi-de of small squares producing an appearance similar to that of a affle-iron. The accuracy of the design and construction of the eckered surface determines the character of the diffusion and the iformity of the illumination. In connection with the design of e lighting system for a moving picture theater,[168] data were ob-ined on the brightness values of parts of the picture itself. Sun-ht on the white clothing of one of the actors was represented in e picture by a brightness of 3.0 millilamberts; a reproduction of etter written on white paper, 6 mL.; title background, 0.06 mL.; th the projection machine running but no picture, the screen ightness was 7.0 mL. The screen brightness as the result of neral house illumination was only 0.01 mL.

[166]Mov. Pic. World, Oct. 7, 1922, p. 512.
[167]Pop. Mech., Jan. 1923, p. 95.
[168]Jour. of A. I. E. E., June 1923, p. 573.

In a new theater which is used for both musical and moving picture purposes,[169] an effort has been made to embody the principles discussed in a paper before this society in 1920.[170] These involved permissible general illumination in the auditorium and graded illumination from the lobby inward while the pictures are shown, together with means for providing satisfactory illumination when the hall is used for concerts. In the auditorium the main object of interest from the lighting standpoint is a large crystal chandelier. In this are mounted 16 concealed 75-watt units throwing light onto the ceiling from which it is diffused and provides an average horizontal illumination of 0.2 fc. with a range from 0.09 to 0.52. The brightness of the luminaire glassware is on the average 0.33 mL. The chandelier itself is softly illuminated to a point which prevents it from being silhouetted as a dark mass against the ceiling, by a few unconcealed lamps operated at a very low voltage. For low general illumination when a concert is being given, thirty-two 150-watt lamps, also concealed in the chandelier throw light on the ceiling while ninety-six of the same size lamps may be similarly used to provide a high intensity of illumination. For brilliant effects or special gala occasions, direct and special lighting with scintillating of the crystals is produced by thirty-six 15-watt and three hundred eighty-four 25-watt lamps in candle and sockets following the contour of the chandelier bowl. Further to equalize the indirect lighting from the ceiling, 100-watt and 150-watt lamps are concealed above the tops of the doors leading from the balcony to the corridors. The mezzanine is lighted chiefly by lights in the cove. All light sources within the region occupied by the seats are completely concealed from the spectators except the few small units previously mentioned. The graduation of the illumination from the entrance to the interior of the auditorium is shown by illumination readings as follows:

| | |
|---|---|
| Main lobby just inside entrance | 15 fc. |
| Center of lobby | 2 fc. |
| Near orchestra foyer | 1 fc. |
| Main vestibule just inside door | 0.23 fc. |
| Orchestra foyer just inside door | 2.1 fc. |
| Orchestra foyer near aisle entrance | 0.09 fc. |
| Central portion of main floor | 0.04 fc. |

[169] Jour. of A. I. E. E., June 1923, p. 569.
[170] Trans. I. E. S., **15**, 1920, p. 645.

The high level lighting of the auditorium gave an average illumination of 0.95 fc.

Present concert hall lighting practice in Germany may be seen in the re-equipment of the Philharmonic in Berlin.[171] The design was turned over to a committee of the German Illuminating Engineering Society, the former lighting having proved unsatisfactory. Six mirror reflectors with 100-watt lamps mounted 17 feet high resulted in a maximum illumination of 65 lux (6 fc.), a minimum of 20.3 lux (1.9 fc.), and a mean of 43 lux (4 fc.). The light output has been increased almost three times with less than half the former wattage.

Complimentary colors are the foundation on which has been built the lighting of one of the most elaborate moving picture theaters as yet constructed.[172] When an object is lighted on one side with a maximum of intensity of one color, the shadow formed behind the object, instead of appearing black, is lighted with a minimum intensity of the complimentary color. Color has also been depended upon by the architect to give an impression of depth where structural limitations prevent actual depth. Primary colors have been used for decoration to a surprising extent. In the main auditorium all lighting sources are concealed, there being no luminaires except those beneath the balcony. Every place where a light source of which 10,400 in varied shapes and wattages are employed may be hidden, holds its battery of spotlights or trough of lamps. Designed especially for the purpose are 780 baby spotlights and lamps operated by a motor driven dimmer. Four colors —red, green, blue, and amber, in the order named—focused in one direction, increase from zero intensity to a maximum and then fade. From the opposite direction minimum intensities, of red and of blue, light the shadows, each color extending over one cycle of the maximum colors, a complete cycle requiring 16 minutes. The color variations are almost limitless. These lights are also used to produce atmospheric effects in connection with stage numbers or musical interpretations.

In an elaborate new theater devoted to vaudeville,[173] in which the modern French note dominates the decorative scheme, lumi-

[171] L. u. L., Mar. 15, 1923, p. 141.
[172] Jour. of Elec. & W. I., Feb. 15, 1923, p. 131.
[173] Lighting Fixtures & Lighting, May 1923, p. 13.

naires have been obtained in harmony with the rest of the surroundings. In the grand hall are five large crystal chandeliers containing 60 lights mounted in tiers and set around the body of the luminaire. Pendants in other parts of the interior are duplicates on a smaller scale. A distinctive feature of the bracket lights in the main hall is an illuminated oval made of crystal with a light back of the oval, while above it are four candle arms draped with crystals. These brackets are placed around the hall while in four corners are torchieres made with carved wood standards and a three-tier effect of candles with crystal-draped arms. Supplementing the luminaires and brackets are many floor lamps. Ten-light luminaires are placed at intervals around the mezzanine and twelve-light glass arm chandeliers are installed in the ladies' room. Under the soffit of the balcony the luminaires are of an umbrella shape about 3 feet in diameter and consisting of a finely detailed metal form filled in solid with crystals, the frame itself being three rows of crystal garlands, pentalogs, etc. In the dome and procenium promenade three-color cove lighting is used. In the dressing rooms, specially designed luminaires adjustable up and down add to the convenience of the actors. In the grand hall is a combination lighting standard and clock 10 feet high in the Italian renaissance style.

Some novel and bizarre effects have been worked into the lighting of an English moving picture theater.[174] The decoration is in the "New Art" style, the colors being daring in harmony and quaint in application. Groups of peculiarly designed lanterns and erratic colorings hang from ceiling bays, and wall brackets and suspended balloon lights and an aerial fountain add to the uniqueness. The ceiling lights are an integral part of the design of the ceiling instead of hanging therefrom and additional light is obtained from the bull's-eye windows in the frieze and from bases around the balcony front. On the exterior a cupola, which dominates the building, is floodlighted by 24 lamps in addition to 6 flambeaux.

During the past few years stage lighting has kept pace with the improvements in the lighting of the rest of the theater. A system developed on the continent[175] is said to simulate convincingly natural atmospheric phenomena on a single background by a combination of electrical and optical effects in conjunction with an

[174]Elec. Rev., Oct. 20, 1922, p. 561.
[175]Ibid, Mar. 16, 1923, p. 406.

rtificial horizon which occupies the whole background of the heater. Floodlights, projectors and spotlights are employed to lluminate the acting area. The system referred to employes a 500-watt lamp provided with a set of two deflectors, the upper nirror reflecting rays which reach it from beneath, the lower one tilizing the lateral rays. The projectors may be suspended bove the stage and colored disks employed to vary the effect. These spotlights have a telescopic lens to concentrate and focus harply on the object of interest. By adding a second lens and bjective, sets of spotlights can be used for projection purposes nd will throw definite pictures on a plane surface. Indirect light-ng is used for the footlights to avoid glare. The "artificial hori-on" may have the shape of a cupola or a surface of a cylinder and s a brilliant white. It can be erected as a permanent structure or s a movable screen. Thousand-watt tubular lamps in special ousings containing colored glass slides are built up in tiers, to make ossible all sorts of color effects from moonlight to the reddish glow f dawn. Cloud pictures as well as other atmospheric effects may e projected on the artificial horizon.

*ransportation*

Approximately 15,000 lamps are required to take care of the ,000 rooms of the Leviathan, "the queen of the American Mer-hant Marine".[176] Festoons and decorative lighting are also pro-ided for. In the public places, such as the social hall, winter rden, swimming pool and dining room, the lamps are concealed cornices. In addition to these cornice lights, the social hall has large glass skylight with lamps above it. Lighting equipment is rovided for the stage in this room. On this vessel, particular atten-on has been given to the illumination in the boiler and engine rooms.

In the report of the Committee on Locomotive and Car Light-g of the A. R. A.[177] at this year's convention, it was recommended hat a smaller bulb be used for the 15-watt locomotive cab light. here is an increased use for train lighting of the 25-watt, 30-volt, as-filled lamp and it has been suggested that both the 25-watt and e 100-watt lamps be added to the list of recommended sizes. To

[176]N. E. L. A. Bulletin, Apr. 1923, p. 209; Ltg. Fix. & Ltg., Apr. 1923, p. 13.
[177]Railway Elec. Eng., July 1923, p. 211.

save space around the gauges in a locomotive cab,[178] one compan is trying out low-voltage automobile lamps in place of the 32-vo lamps ordinarily employed. Special holders have been designe considerably smaller than those previously required, thereby ob taining the desired space saving. A similar experiment (usir 6-volt lamps) has already been tried out on another road.

*Offices*

In remodeling the lighting of a large office and showroom,[179] has been found possible to replace 1068 gas mantles by only 25 the gas consumption being reduced from 1068 to 1008 cu. ft. p hr. and still obtain twice the light previously available. Ten lar wrought-iron luminaires equipped with 16 burners carrying thr mantles each have been converted into the semi-indirect type b putting white glass panels in the lower cast iron bracket and in th lower outside ring. A 9-mantle burner has been employed and th floor illumination increased from 3.5 fc. per sq. ft. to 6 fc. In th clerical space eighteen 10-light luminaires were used giving a illumination of 4.5 fc. at desk height. These fittings have been r modelled to the indirect type and equipped with a 9-mantle burne The result has been 8.5 fc. at desk level.

*Stores*

A survey[179a] of lighting conditions in the retail stores of a lar middle western city showed only 25 per cent with an illuminati of 5 fc. or better and only 2 per cent with illumination of 10 f Since then this condition has been changed so that in cigar stor the illumination has been raised from 6.9 to 14 fc.; in groce stores from 3.8 to 8.1 fc.; in drygoods stores from 5.8 to 7.5 f and in tailor shops from 3.4 to 8.1 fc., and in other stores up 10 fc. Tests of the illumination provided by a new installation a department store [180] showed on the first floor an average of 12 f directly beneath the luminaire and 6 fc. directly between uni Similar readings on the second floor gave 10 and 4 fc. The lun naires were pendant enclosing globes of three-layer cased glass a were located one in each bay and down the centers of the aisles 24-foot intervals. The average ceiling illumination was 22 fc.

[178]Ibid, Feb. 1923, p. 45.
[179]Gas Age-Rec., Jan. 13, 1923, p. 37.
[179a] Elec. Rec., Jan. 1923, p. 11.
[180]Ibid, Apr. 1923, p. 248.

the first floor and 18 fc. on the second. Mounting heights were 12.5 and 11.5 feet, respectively, 750-watt lamps being employed on the first floor and 500-watt lamps on the second.

The use of pedestals for indirect lighting luminaires[181] has become more or less common in the case of public halls, restaurants, etc., but an English store has adopted this method of avoiding obstructions on the ceiling. The standards are of wood 7.5 feet high fitted with three mirror reflectors and especially designed by the architect to harmonize in finish and character with the other woodwork. The main units are supplemented by other mirror reflectors on the tops of shelves. In a room on the top floor lighted by a skylight, reflectors placed above the glass provide a night illumination of the same intensity as that of daylight.

A different window lighting effect for every night in the year[182] is obtained in an eastern store by the use of 16 circuits in the window, 12 overhead and 4 at the floor, and 9 flashers. Spotlights with ball and socket joints and fitted with 200-watt lamps give light at any angle and at any desired spot. Each unit has four color effects available at any angle in a hemisphere. One of the luminaire display circuits is arranged so that when the window and sign lights are put out, one or more luminaires may be made to flare up against an attractive background.

*Factories*

That there is still a great deal of improvement possible in all classes of lighting in England,[183] both in the industrial and residential spheres, is indicated in an address on the subject of salesmanship and lighting before the Electrical Development Association. The speaker asserted that there are probably only 30 per cent of the factories in that country which "have proper lighting equipment." He spoke of one case in which this condition had been corrected. A factory manager had requested a demonstration of artificial lighting which would approximate daylight as given through a north skylight. The daylight measurement showed 20 fc. and by using 200-watt lamps in industrial reflectors on 10-foot centers, an illumination of 15 fc. was obtained and accepted as

[181]Elec., Jan. 26, 1923, p. 95.
[182]Electragist, Aug. 1923. p. 29.
[183]Elec. Times, Oct. 19, 1922, p. 357.

satisfactory. While great strides have been made in the lighting o offices and public buildings, generally speaking the intensity o illumination is far too low and the standard of equipment used very poor. There are still in existence tens of thousands of drop pend ants.

Comparison of production[184] in a textile-spindle shop under daylight and under directed artificial light indicated 25 per cent in crease in the latter case. Straightening of the spindles after grinding is a hand operation which it was found difficult to perform satisfactorily under conditions of varying daylight. An ordinary shaded lamp was tried but was not satisfactory because of reflec tions on the spindle. An angle reflector with a 150-watt lamp solved the difficulty when a silvered reflector-cap diffuser was placed over the side and end of the lamp so as to shade in the direc tion of the work. The result was no glare or disturbing reflections As all production of the plant centered on the spindle straightener an increase in his work resulted in an increased plant output.

Numerous methods have been worked out in the past for in creasing the brightness of the field of view of the microscope.[185] Another step in this direction is the use in the coaxial illumination systems, of an "azimuth" illumination screen, where by "azimuth" is meant a direction perpendicular to the axis of the microscope.

*General*

Colorimetric chemical analysis by the use of "indicators" has been difficult under artificial light[186] but some of the troubles have been remedied by the use of artificial daylight. Tests have in dicated an accuracy with the latter in some cases equal to, but in many cases even greater than by daylight.

Some data on comparative values of oil and electric light have been obtained[187] by the Agricultural Department of the University of Wisconsin. A working farm foreman did his usual routine work by kerosene oil lamp one night and by electric light the next. The results are shown in the following table:

[184]Elec. World, Dec. 30, 1922, p. 1450.
[185]Phys. Zs., Feb. 15, 1923, p. 91.
[186]Analyst, Oct. 1922, p. 424.
[187]Elec. Rev., May 25, 1923, p. 807.

| Operation | Minutes for Operation | |
|---|---|---|
| | Oil | Electric Light |
| Stabling cows | 4. | 3 |
| Cleaning mangers | 9.5 | 7 |
| Weighing and feeding grain | 31.75 | 12 |
| Feeding silage and hay | 39.25 | 35 |

It should be noted that there are a good many factors which should be taken into account when drawing conclusions from these data.

### LUMINAIRES

The adoption of the term "luminaire"[188] to replace the word "fixture" in the lighting industry seems to be very slow in spite of the efforts of this Society. At the winter convention of the National Council of Lighting Fixture Manufacturers,[189] it was pointed out "that the word 'fixture' was a handicap to the expansion of the industry" but instead of replacing it by the word "luminaire" it was suggested that the term "lighting equipment" be its successor.

In the exhibition of luminaires at the convention just referred to, the shower type was quite generally represented but the candelabra idea still predominated. A decided advance was noted in wrought-iron pieces. More attention is being given to special designs for individual types of public buildings.[190] Thus for church lighting, a finish in the Gothic is given to luminaires made especially for churches in the Gothic architecture. A growing use of torchiers is indicated by the new designs in this class of lighting unit.[191]

*Gas*

A fitting which converts an open-flame gas jet into a mantle-type burner[192] has a goose-neck which is screwed on in place of the open flame outlet and is of such dimensions that it will fit inside the standard shades or globes. The shade holder may be used for direct or indirect lighting depending on whether it is placed below or on top of the globe. In the latter case, it is suspended by a threaded knob on top of the goose-neck.

[188]Lighting Fixtures and Lighting, March 1923, p. 26.
[189]Ibid, Feb., 1923, p. 15.
[190]Ibid, Dec., 1922, pp. 5, 6.
[191]Elec. Rev., Aug. 1922, pp. 97, 102.
[192]Pop. Mech., Sept. 1922, p. 330.

An inverted super-heated gas luminaire of the cluster burner type for general commercial use has been worked out on the basis of being dust- and insect-proof.[193] The air is drawn through three tubes from the base of the corona band which carries the glass globe into a mixing chamber on the center down rod leading to the injector tube. The burner is fitted with three mantles controlled by one tap and may be used interchangeably with any of the three standard sizes of mantles. The unit is said to give a light of from 500 to 700 cp. In order to prevent dust collection above gas luminaires, a special burner[194] deflects the heat from the gas flame so that it is projected at an angle outward from the bowl. A small mica baffle suspended below the burner catches the mantle if it breaks or drops from the holder.

*Street Lighting*

The increased size of incandescent lamps available for street lighting has hastened the retirement of the cluster standard in favor of the single light unit.[195] For the latter a much more attractive architectural design of the post is possible and it is now largely used for "main street" lighting. A distinct change is also noticeable in the character of the glassware which has expanded from a globular form to the urn-shape, while the tops are covered either with reflector canopies or the glass is so designed as to redirect light thrown upward and formerly wasted. There has been an increased use of alabaster rippled globes.[196] A new glassware has a surface made up with a number of rectangular protuberances which tend to diffuse the light without materially altering its direction, and is made in clear crystal or slightly opalescent material. The trend toward panelled lanterns continues and several types are now available. A new type of bowl refractor for pendant units has a distribution which tends to build up the light laterally while at the same time adequately illuminate immediately below the unit. Experiments are being made on a design for an assymetrical refractor which will build up the light longitudinally allowing only a small portion to be directed across the street. New designs of ornamental post-top units have also been brought out,

[193]Gas. Jour., Oct. 25, 1922, p. 226.
[194]Pop. Mech., Jan. 1923, p. 113.
[195]Elec. Rec., Apr. 1923, p. 217.
[196]Report of Lighting Sales Bureau, N. E. L. A., June 1923.

the light distribution being controlled by upper and lower parabolic reflectors arranged to give a maximum distribution 20° below the horizontal. These are said to be particularly adaptable for 50 foot to 100 foot spacing. A new highway unit, totally enclosed, has the lamp at the focus of a parabolic reflector which redirects the light vertically downward upon two refracting prism surfaces and thence to the roadway in two directions.

*Industrial*

Through the cooperative efforts of a number of reflector manufacturers, glassware makers, and illuminating engineers, an addition has been made to the type of equipment for industrial lighting which has become more or less standardized. It consists[197] of an enameled steel reflector with a glass diffusing globe which completely surrounds the lamp. Sections of the upper portion of the steel reflector are cut away permitting about 7 per cent of the light to reach the ceiling and thereby avoid harsh contrasts. It is available in two sizes, the reflectors of which are 18 inches and 20 inches in diameter respectively. The smaller size takes 100– to 200-watt lamps, the larger, 300– to 500-watt. A standard socket adapter makes the larger reflector adaptable for smaller lamps by extending the light center length. The brightness is given[198] as 2 to 5 per sq. in. and the efficiency as 65 per cent. Both the bowl and the shallow dome type of industrial reflectors[199] have been adapted for use with the so-called "mill" type incandescent lamp on pendant or portable cords or for permanent local lights.

A special heavy duty reflector[200] has been designed for industries where it is desired to have strong illumination concentrated on machines with enough "spilled" light to illuminate the aisles and passageways. The unit is nearly 12 inches in diameter, 6 inches high and carries an adjustable holder so that it may be used with lamps of various sizes from 75 to 200 watts. With a 200-watt clear lamp, 1200 cp. are obtained directly beneath the reflector, 850 to 900 cp. at 30° to the vertical and 400 cp. at 45°, It will be noted that there is a rapid falling off after 15° and the cut-off is at 60° to eliminate glare.

[197]Elec. Rec., Feb. 1923, p. 108; Central Station, April 1923, p. 300.
[198]Elec. World, Jan. 6, 1923, p. 27.
[199]The Electragist, Aug. 1923, p. 50.
[200]Elec. Rec., Mar. 1923, p. 183.

When the standardized steel dome reflector was first brought out[201] tests of seven standard types covering the mechanical, thermal and illuminating properties showed quite a variation. This condition has been remedied to such an extent that it is felt that the choice of these reflectors may be made on the basis of their thermal and mechanical characteristics since the illuminating properties are very closely the same for different makes.

An effective method of making the letters stand out[202] has been employed in a sign made up for use in interiors such as banks, offices, etc. The surface of the letters is flooded by light through an aperture just below them while light from the same lamp reflected by a mirror is diffusely transmitted through them. Due to the double illumination, the contrast between the letters and their background is quite sharp and the legibility clearly heightened.

*Luminaires*

A dual distribution of light is obtained from a semi-indirect luminaire which has a bowl of an ordinary semi-indirect type 13 inches in diameter of heavy density tinted opalescent glass. At the bottom, a circular section has been removed[203] and replaced with a piece in the nature of a lens made of crystal glass. The latter tends to concentrate the downward light into a relatively narrow beam such as might be desirable for lighting a dining room table. A decorative husk covers the lamp socket and the whole is suspended by a chain.

Prismatic glass is used[204] in a totally enclosed semi-direct decorative bowl luminaire made in two parts. The exterior surface is smooth and plain, control of the light rays being effected by an interior prismatic construction designed to minimize glare and give wide distribution. The top diffuser, besides protecting the lamp and the prismatic surfaces from the accumulation of dust, diffuses the upward rays which light the ceiling. The lower diffusing zone has a permanent enameled inner surface with an ornamental exterior design.

A luminaire[205] designed especially for the kitchen has a ceiling fitting and holder of white porcelain enamel or steel. Set screws to

[201] Elec. World, Aug. 12, 1922, p. 330.
[202] Pop. Mech., Jan. 1923, p. 72.
[203] Elec. Rec., Nov. 1922, p. 303.
[204] Elec. Rev., Dec. 15, 1922, p. 923.
[205] The Electragist, Aug. 1923, p. 48.

hold the glassware are avoided by a spring holder with no dirt accumulating projections. A white diffusing glass 9 inches in diameter with a 5-inch filter permits the use of lamps up to the 150-watt size.

*Hospitals*

An apparatus designed especially for use in operating rooms of hospitals, clinics, etc., has been brought out in Germany.[206] A gas-filled projector type of incandescent lamp has its filament adjusted in a parabolic mirror so that the outgoing rays are parallel and fall on two plane mirrors from which they are reflected to the spot under examination, one mirror reflecting rays from the upper half, the other from the lower half of the reflector. The latter is surrounded by a cylindrical cover to prevent stray light. Arrangements are provided for color filters to give daylight quality to the illumination. Another hospital light designed to throw a powerful but cool and shadowless illumination on the subject[207] employs a 100-watt lamp and covers an 18 inch ring on the table. It consists of a dioptric lens fitted at the center of a metal saucer around the rim of which are a number of silver reflectors. The lamp holder at the top of the fitting has a quick release catch for changing the lamp and is adjustable to any standard type of lamp. The bottom of the luminaire is closed by a screen of tough glass. A lamp arranged especially for therapeutic work[208] has an adjustable hood which may be raised to a height of 7 feet, is mounted on a lazy tongs and is counterbalanced. The 1500-watt incandescent lamp can be moved for focusing in four positions. At the lowest position an even diffusion of light results while at the highest a markedly hot area is apparent.

*Portables*

A new adapter[209] which may be easily attached to a floor or table pedestal or used to convert an oil lamp to an electric or to make a lamp out of a vase has a top part in the form of an inverted mirror bowl reflector. Below this is an inverted cone type of diffusing glass which throws out sideways and downwards, light

[206]L. u. L., Feb. 1, 1923, p. 58.
[207]Elec. Rev., Oct. 13, 1922, p. 536.
[208]Elec. Rec., Nov. 1922, p. 302.
[209]Elec. Rec., Oct. 1922, p. 220.

from two or more lamps in sockets just below it. The adapter is intended for use with art glass or cloth shades and is equipped for lamps from 75- to 200-watt in size in the reflector and 15- or 25-watt frosted lamps in the outer sockets.

An exceedingly novel table lamp[210] has a shade and standard made of cows' horns, the latter having been rubbed down with emory until transparent enough to show their natural color by transmitted light. The finished product is said to be of a very pleasing and mellow glow.

A small lamp which can be used as a clamp lamp,[211] a stand lamp or a suspension type for the wall is made to swivel and angle and can be placed and will stay in any position at will. It has a ball and socket joint and a counter-weighted base which holds the lamp firmly either in the vertical position or swung through an arc of 90°. The clamp works on a flat screw. Another portable lamp for the living room[212] has an arm supported by a thick braid which may be fastened to the wall by a thumb tack or hook and adjusted by sliding it up or down on the braid. The arm can be fixed so that the lamp lies flat against the wall as a wall lamp or extended over a chair, desk or dresser. The lamp shade is made up in a combination of braid and mica tinted in colors to make the whole look artistic.

An electric lamp for use around automobiles or by campers[213] is made up like an old-fashioned trainman's lantern. It is provided with three standard unit dry-cell batteries concealed in what would have been the oil reservoir. It can be set or hung anywhere and has a practically unobstructed light beam except in the direction of the base.

*Accessories*

For use in shades an impregnated silk is available[214] which is said to be stiffer, to have improved qualities of diffusion, and to be more readily cleaned than material ordinarily used, as well as being practically non-inflammable. So much effort has been expended in designing luminaires so that the lamps will be kept free from dust and dirt that it is not surprising that some energy has

[210]Pop. Mech., Oct. 1922, p. 604.
[211]Elec. Merch., Jan. 1923, p. 3063.
[212]Elec. Rec., July 1923, p. 42.
[213]Elec. Merch., July 1923, p. 3510.
[214]Illum. Eng., Nov. 1922, p. 307.

been deflected to produce a protector for the handsome silk or other cloth lamp shade which adorns a table lamp.[215] This protector is made of a transparent durable material which is said to have the transparency of glass and is impervious to the finest particles of dust. These covers range in size from 18 to 30 inches in diameter, and can be obtained in white, old rose, blue, or gold colors. A hanger for an ornamental dining room luminaire of the general dome type[216] is made of wood fiber finished in antique silver.

In order to convert a direct lighting luminaire[217] to an indirect without discarding the old chain or reflector, a device has been worked out which has the form of a bent rod carrying an ordinary plug at one end which screws into the existing socket; at the other end is an inverted socket into which the lamp is screwed, and which carries the reflector or globe holder. The whole is concealed by a silk shade.

The electric-light switch plate[218] as mounted on the walls of a residence is ordinarily finished in brush brass or bronze and is not decorative in character. Attention has been given to this small feature of the room equipment and plates are now being hand-painted in four color combinations and radium treated to make them easily found in the dark. Another opportunity for decorative improvement has been found in the pull chains for floor and table lamps.[219] These chains formerly ending in a button or knob may now be fitted with a colorful object such as an owl or a humming bird, a bit of rare rock or amber or the chain may be a string of beads of various colors. A still more elaborate touch is the switch operated in the old-fashioned bell-rope style. This switch pull is a long-woven silk ribbon hanging against the wall and reaching to the ceiling. It is made in mulberry, rose, old gold, and other colors.

A screwless shade holder[220] for luminaries has on the inner surface of the holder three spring fingers. These fingers are forced inward against the outside lip of the bowl by means of a simple locking ring. To facilitate the installations of window lighting reflectors a square steel tubing already wired is obtainable.[221] The

[215]Elec. Merch., June, 1923, p. 3453.
[216]Elec. Merch., Jan. 1923, p. 3063.
[217]Ibid, Aug. 1922, p. 109.
[218]Ibid, Nov. 1922, p. 114.
[219]Ibid, Apr. 1923, p. 3245.
[220]Lighting Fixtures and Lighting, Mar. 1923, p. 42.
[221]Pop. Mech., Dec. 1922, p. 898.

contractor installing the equipment merely sends the dimensions and location of the outlets to the manufacturer and receives the tubing prepared so that all that is required is the connection of the wires at the end to the lighting main and the placing of a few hanger screws.

An automatic electric time switch[222] which turns street lamps on and off at predetermined times has been amplified so that it takes care of seasonal variations on the lighting schedule. The device follows the sun and automatically controls the clock mechanism which operates the switch.

A very simple device for locking incandescent lamps[223] against removal by theft has come out in Germany. A hole is bored through the shell of the lamp socket and the threaded part of the lamp base. A split ring has an inside projection which fits into these two holes. As the lamp is screwed in, this projection follows the threads until the hole in the base is reached when it snaps in. The lamp must be broken to remove it. Numerous other devices to prevent stealing have been brought out in that country. One of these[224] has an elaborate arrangement of adjusting rings, each carrying on its circumference ten letters which must be oriented properly to permit the lamp to be removed after it is once set.

A change has been made in the condenser which is part of the projection apparatus employed with incandescent filament lamps in moving picture work.[225] Sufficient glass was taken from the center of the condenser to make the two halves slightly offset the images of the filament, thereby interposing on the curtain the bright bands of one field on the dark bands of the other. An evenly illuminated surface is claimed together with a greatly increased picture illumination due to greater possible concentration of light on the film.

*Cleaning and Ventilation*

The effect of dirt in general on decreasing the efficiency of lighting installations[226] is a matter of common knowledge but a recent investigation undertook to classify the kinds of dirt which

[222]Elec. News, Aug. 15, 1922, p. 41.
[223]E. T. Z., Apr. 19, 1923, p. 367.
[224]Elek. Anz., Sept. 16, 1922, p. 1167; Helios, Sept. 17, 1922, p. 3119.
[225]Gen. Elec. Rev., Jan. 1923, p. 51.
[226]Indus. Eng., Jan. 1923, p. 46.

accumulate in representative industries, and to determine the effect of cleaning. Typical lamps were obtained from automobile, paint and varnish, chemical and storage battery industries, machine shops, factories, transportation offices and warehouses. Sixty per cent of the companies visited did not clean their lamps at all, 33 per cent cleaned at infrequent intervals, and only 7 per cent cleaned frequently at regular intervals. Four separate classes of dirt were encountered—dust and dry dirt, smoke, etc.; oily dirt and grease; paints tar, varnish, and pitches; and acid fumes—given in the order in which they most frequently occur. The average per cent increase in illumination after wiping was 77.7, 84.7, 37.2 respectively; and the average per cent increase after washing was 78.4, 47.0, and 67.2, no measurements being made on the lamps coated by acid fumes.

The effect of dirt is just as important in reducing the illumination due to natural lighting passing through windows, skylights, etc., as in the case of artificial illuminants. When clean the various ribbed, rippled, pebbled, and clear glasses employed in industrial plants transmit from 70 to 90 per cent of the incident light. The accumulation of soot dust, rust etc., reduces this transmission very quickly. Tests on seven sample glasses just as they were taken from shops and after they were cleaned showed that the daylight illumination in these plants would be increased from 4 to 15 times if the entire glass were cleaned.[227]

Additional evidence has been obtained in a northern city[228] of the desirability of not ventilating street globes containing 400- to 500-cp. lamps. Ventilated globes allowed the entrance of snow and caused lamp failures. The non-ventilated units were found to radiate enough heat from their exposed surface to avoid harmful temperature rises.

## PHOTOMETRY

The photometric work done by the German Bureau of Standards (P. T. R.) in 1921 involved testing 47 hefner lamps,[229] 40 carbon and 335 metal filament lamps, 3 glimm and 1 mercury vapor lamp, 3 kinds of carbons for direct current arcs and 2 metallic reflectors. Forty-two materials were examined for light lost by

[227] Jour. of Frank. Inst., Oct. 1922, p. 546.
[228] Elec. World, May 26, 1923, p. 1222.
[229] Elek. u. Masch., Dec. 3, 1922, p. 571.

reflection and absorption. The carbon lamps and 235 of the meta filament lamps were used as standards. Work has also been done[23] on the proposed light unit based on black body radiation at 1700 absolute and wave-length, 0.656. The result indicated the desir ability of using a higher temperature and shorter wave-lengths.

At the National Physical Laboratory, England, the work o ships' navigation lights has been continued.[231] An experimenta building has been constructed for the investigation, by means o scale models, of problems in the natural and artificial lighting o buildings.

*Units*

To realize the black-body standard of light[232] a special furnac has been constructed in which the carbon heater tube operates in vacuum and has cooled copper conductors fitted into its slotte ends to make as positive a contact as possible. Contact pressure i obtained by an elastic ring of heat-resisting steel embedded in th entrance of the tube.

The hefner lamp is the official standard for maintaining the uni of light in Germany.[233] The effect of barometric pressure on th light intensity of the hefner has been determined a number of times notably in 1911 when the work was done in a pneumatic chambe A new investigation has been made at four different altitudes– Vienna, (165 m.), Böckstein (1125 m.), Maserboden (1965 m.), an Sonnblick (3100 m.). Three lamps certified by the P. T. R. wer used in the test and the results showed an average change of 0.000 h.c. per mm. change in the barometric pressure, exactly confirmin the data previously obtained in the pneumatic chamber.

*Instruments*

A new lumen-meter or lux-meter has been brought out i Germany.[234] An effort has been made to combine the convenienc of the most portable types already in existence with the accuracy o the more complicated instruments. Errors of measurement ar said to be of the order of 5 per cent to 10 per cent. The compari son lamp is held in a small box and operated at reduced voltag

[230]Zs. f. Instr., Mar. 1922, N. P. R.
[231]Elec. Rev., July 6, 1923, p. 37.
[232]Zs. f. Beleuch., *28*, 1922, p. 76, u.s.w.
[233]Elek. u. Masch., Oct. 29, 1922, p. 511.
[234]L. u. L. Apr. 26, 1923, p. 207.

giving a reddish light but long life and constancy. It illuminates the whitened interior of a box which at the end opposite the lamp is closed by a piece of blue glass in contact with a milk glass plate. The resultant color matches that of a tungsten lamp at normal voltage. The box is divided into two parts separated by a partition containing a series of small circular holes, and a disk with a corresponding series of the same sized holes. Moving the disk by a knurled wheel operating a worm changes the extent to which the holes in the disk coincide with those in the partition and thus changes the amount of light which reaches the milk glass screen, in steps which can be calculated. This screen is seen in one half of the circular observation field, the other half being a white (barium sulphate) screen which receives the illumination to be measured. The field is observed at an angle of 35° or 40°. To increase the range from 10 to 100 lux, the barium sulphate receiving screen is replaced through the rotation of a disk, by one which reflects only 10 per cent of the incident light, while higher values may be measured by using other screens of still greater absorption power. In this way illuminations of 1 to 500 lux may be measured. Lower illuminations are taken care of by interposing a dark-blue glass plate in the comparison lamp beam. The total range of the instrument is given as from 0.01 to 500 lux. The whole is contained in a portable case which also carries the dry battery for operating the comparison lamp.

Improvements have been made in the shadowmeter[235] (Schattenmesser) described in the Report for 1920[236] and used for illumination measurements. A thin curved "shadow caster" makes the angular diaphragm and a "shadow seeker," consisting of a needle placed perpendicular to the center of the disk, determines the direction in which the individual light sources throw shadows on the working plane. The cube instead of the sphere[237] for total luminous flux measurements has been the subject of study in England for some years. An extension of this idea is a so-called lumen comparator which consists of a rectangular box painted white on the interior and divided into two cubical portions by a central diaphragm which also divides the observation window. The lamps to

[235]Zs. f. Beleuch., 27, 1921, p. 109, M. P. R.
[236]Trans. I. E. S., 15, 1920; p. 473.
[237]Ill. Eng., Oct. 1922, p. 283.

be compared are placed in the two divisions and comparisons made between the relative brightness of the two windows.

Another photometric device[238] is a modification of the integrating photometer described in the Report for 1919 (Trans. I. E. S. 14 1919, p. 370) and employs a square or rectangle as the geometric outline to support the diffusing plates instead of the circle.

Photometric equipment[239] for use with the Ulbricht sphere designed along somewhat similar lines to those of a foreign apparatus referred to in the 1918 Progress Report has been made in this country. A suitable comparison lamp is enclosed in a rectangular box whose interior surfaces are painted with the same paint as that in the sphere. In the end of the box toward the photometer head is an opal glass window, in front of which moves vertically a metal slide with a V-shaped opening and back of which are two broad horizontal bars forming an adjustable space between them. Thus the area of the window may be altered continuously and in turn the illumination on the photometer screen from which it is some 30 cm. distant. The slide with the V-shaped opening carries three photometric scales. The apparatus has been modified by removing the opal glass from the window in the box and placing the lamp out of the line of view of the photometer which then receives its illumination from the back wall of the box.

A spectrophotometer,[240] constructed primarily for the measurement of spectral reflection from surfaces, consists of a hollow sphere containing four incandescent electric lamps illuminating indirectly a sample and a standard white. The light from the two fields is reflected through a rotating sectored diaphragm and into a spectrometer. By this means the ratio of the light reflected by the sample to that reflected by the standard is measured in the different wave lengths. Another spectro-photometer measures the spectral transmission of liquids. It consists of a constant deviation photometer in combination with an "exponential" or "variation of thickness" photometer. A unique feature of the latter is the use of two totally reflecting, partially immersed rhombs, so that one of the two beams of light employed is diverted through a variable thickness of liquid depending on the thickness of the rhombs. The instrument is

[238] Elek. Zeit., July 12, 1923, p. 665.
[239] Jour. of Frank. Inst., Oct. 1922, p. 543.
[240] Jour. of Opt. Soc. of Am., Jan. 1923, p. 98.

direct reading in transmissivity, log of transmissivity, and wavelength. It does its own computing automatically and a spectral curve may be determined and plotted in a few minutes. It is expected that this instrument will be of special value in technical examination of oils, dye solutions, sugar solutions, etc.

*Heterochromatic Photometry*

It is well known that where the sources compared are considerably different in color[241] corresponding to black-body distributions at wide intervals of temperature, the Crova method involves errors of appreciable magnitude. A modification of this method permits comparison where the color differences corresponding to temperature differences are as much as 2,000°. A standard is employed whose temperature can be determined and hence the relative intensity at different temperatures computed for the Crova wavelength 0.582$\mu$. The ratio of the emission at this wave length of the unknown to that of the standard, if raised to the 1.015 power, will give the correct ratio of the luminous intensity to within less than 2 per cent. This formula can be used for a standard whose temperature lies between 2000° and 3000°. A more elaborate formula based on the De Lepinay method using measurements at two wavelengths is suggested for standards whose temperature limit is beyond 3000°.

Another solution of the difficulties of heterochromatic photometry[242] is offered in a color-match photometer, a three-color mixture instrument in which the primaries are of equal luminous value and of just sufficient purity to reproduce by their mixture all of the common illuminants. The optical arrangement is such that the illumination of the comparison field remains constant as the color is varied to match the standard or test illumination. A 400-watt projection type incandescent lamp is employed in which the parts of the filament are in one plane. An image of the filament is focused on a ground glass window in a hexagonal box with whitened interior walls. The light diffused by the window helps to illuminate one side of the box, the remaining illumination coming from the other walls. Opposite the window the box is closed by an extended white surface illuminated by the source to be measured. This surface and the side of the box are observed by means of a photometric

[241] Compte Rendu, Oct. 23, 1922, p. 688; Rev. d'Opt., Feb. 1923, p. 42.
[242] Jour. Opt. Soc. of Am., Jan. 1923, p. 75; Mar. 1923. p. 243.

prism and an optical train. The composition and intensity of th light falling on the diffusion chamber are controlled by colore glasses and a variable aperature slide. This instrument is said t make possible the determination of the most difficult part of monc chromatic analysis measurements, namely the illumination value of the color and its constituent white. Methods and diaphragm have been developed for transforming trichromatic data to othe sets of trichromatic primaries and to the monochromatic systen and the graphical methods are applicable to measurements c illuminants.

Another comparative study has been made of the flicker an equality-of-brightness methods of color photometry.[243] Fou spectral lights were photometered against a 32 cp.—4.85 wp carbon lamp by the two methods with illumination of 12.5, 2 and 50 mc. The rise in sensation in just noticeably different ste of brightness was determined for each of these lights and intens ties with the same observers and state of adaptation of the ey The effect of variation in intensity was determined by using seve values including the three previously mentioned. One intensit was found for each pair of lights at which agreement occurred wit the most sensitive speed of rotation of the flicker disk. Values c this intensity were found to be widely separated for the four pai of lights. Each pair of lights was rated by the equality-of-brigh ness method with a length of exposure equivalent to that of the i dividual exposures used in the flicker method. In these case agreement of the two methods was obtained within the limits c judgment between 0.4 and 1.5 per cent for the flicker and 1.3 t 2.7 per cent for the brightness method. It was concluded amor other things that "no differential summation effect is produced b the succession of exposures used in the method of flicker."

For the measurement of the light absorption of solutions,[244] compensation principle employing two photoelectric cells enabl the null method to be used. With this arrangement and a mercu vapor lamp as a source, the absorption of solutions of potassiu chromate in caustic potash, copper sulphate in ammonia, azobe zene in alcohol, for the mercury lines between 0.254 and 0.579 was determined.

[243]Psych. Bul., Feb. 1923, p. 87.
[244]Zs. f. Physik. Chem., 100, 1922, p. 208.

*Computations*

Using mathematical processes[245] based on the theory of the integrating sphere, a series of formulae have been developed for the determination of the effect on illumination of diffuse reflection from walls and ceilings of enclosures of various shapes. Corrections have been worked out for the effect of corners and other irregularities. Another monographic chart[246] has been worked out for the solution of problems of illumination design, based on a method of computation referred to in the 1921 Report of this Committee. The chart is said to simplify the operation of computation and eliminate the use of all tables of coefficients and angles without sacrificing any of the accuracy of the method. The latter is equally applicable to direct or indirect lighting, either by using the distribution curve of the luminaire, or foot-candle values in one plane, and enables the determination either of the proper height of the luminaire or the necessary luminous intensity of the unit.

PHYSICS

In that branch of physics of particular interest to the illuminating engineer, the subject of luminescence seems to have been given an unusual amount of attention during the past year. The subject has been studied from the standpoint not only of its production but also of the many factors which influence its character. The nature of fluorescent light is such that it is not unreasonable to suppose that the next big advance in the development of an efficient source will come from this great class of light producers.

*Light Sources*

Further experiments on the emissivity of platinum and tungsten[247] using the micropyrometer method, have shown that the emissivity is independent of the temperature for platinum between room temperature and 1710°C and for tungsten between 2000° and 3200°C. The values at $\lambda = 0.647\mu$ were 0.348 for platinum and 0.49 for tungsten; at $\lambda = 0.536\mu$, they were 0.363 for platinum and 0.49 for tungsten. The melting point for tungsten was also determined and found to be 3370°C ± 50°.

Several years ago it was discovered[248] that a fine wire through which is passed the discharge of a high voltage condenser vaporizes

[245]E. T. Z., Oct. 12, 1922, p. 1262.
[246]Elec. World, Apr. 7, 1923, p. 801.
[247]Zs. f. Physik., June 16, 1923, p. 63.
[248]Proc. of Nat. Acad. of Sci., July 1922, p. 231.

as if exploded, with a flash of light, the radiation of which corresponds to that of a black body at a temperature of about 20,000°K. A spectral study of this light, using wires of Fe, Cu, Ag, Au, Mg, Zn, Cd, Al, Sb, Pb, Ni, T, gave for all a continuous spectrum of the same general intensity.

So much comment has been made from time to time on the ultra-violet radiation in the ordinary artificial light sources[249] that information on the amount in sunlight is of value and interest. Measurement on this subject, corrected for absorption in the solar atmosphere and using the positive crater of an arc for a comparison source, gave the following results:

| Wave-length | Ratio Sun/Arc | Temp. Abs. of Sun |
|---|---|---|
| 0.3940$\mu$ | 40 | 6016° |
| 0.3620 | 50 | 5931 |
| 0.3143 | 79 | 5832 |
| 0.3022 | 112 | 5959 |
| 0.2922 | 134 | 5970 |

The temperature of the arc crater was taken at 3750° absolute. The sun temperature was computed assuming the energy distribution of the arc to be that of a black body at the same temperature.

The color temperature of daylight[250] has been determined by the rotary dispersion method. The comparison source had a color temperature of 2848°K. For the northwest sky, the color temperature varied from 6870°K for a uniformly overcast condition to 24150°K for a clear blue state. A horizontal surface illuminated by the whole sky showed a color temperature of 6500°K for a bright overcast condition, 7225°K for a broken overcast condition with pale blue on one day to over 25,000°K on another day with pale blue above and the horizon hazy. On a day with direct sunlight and a bright light haze in the atmosphere, the color temperature was 5300°K. Measurements of the brightness of the moon[251] and the color temperature of moonlight gave for total light 0.24 c per cm.$^2$ and a temperature of 4125° absolute. Taking the color temperature of sunlight as 5600° absolute, the difference indicates the selectivity of the observed area of the moon, the reflecting power for total light being 0.07.

[249]C. R., July 17, 1922, p. 156.
[250]Jour. of Opt. Soc. of Am., Jan. 1923, p. 78.
[251]Nature, Apr. 21, 1923, p. 532.

A continuation of the earlier work on the effect of temperature on the current in discharge tubes[252] has been obtained with gases other than air. With hydrogen and carbonic anhydride, the increase in current with increase of temperature was found to be much more marked than with air. The temperatures employed ranged from $-180°$ to $275°$C.

A report has been made to the Optical Society of America on stellar and planetary radiometry[253] which reviews knowledge obtained since 1920 on the radiation intensity and temperatures of the planets. A bibliography is included.

*Luminescence*

On the subject of luminescence, reference should be made[254] to a Bulletin of the National Research Council which discusses present knowledge and contains an elaborate bibliography.

If tungsten is used as an anode[255] in a concentrated solution of $H_2SO_4$ with an applied voltage of 60, a faint but continuous luminescence appears about the tungsten. The effect seems to be associated with the conversion of $WO_2$ and $W_2O_5$ found at low voltages, into $WO_3$. The luminescence is of the same nature as that observed when pyrophoric $WO_2$ is oxidized in the air. In solutions where the oxide film is at once dissolved as in 30 per cent NaOH, no luminescence was found. A preliminary study of 70 substances[256] to see what part of the ultra-violet spectrum excites fluorescence revealed the fact that the oxides (20) and simple chlorides (8) were not excited. A few substances (7), including Zn and Cd compounds, fluoresced faintly while the uranyl compounds fluoresced strongly. For the last group, the effective exciting spectrum extended from $0.55\mu$ to $0.35\mu$ only, while for the others it went continuously to $0.2\mu$ except in a few special cases.

There are impurities in the Missouri calcites[257] which include magnesium, zinc, and the rare earths. Phosphorescence has been excited in these calcites by the molybdenum arc whose characteristic wave-length is $0.379\mu$. Exposure in a mineral cabinet for about twenty years has caused an abatement but not an oblitera-

[252]Elletrotecnica, Aug. 15, 1922 p. 507
[253]Jour. of Opt. Soc. of Am., Dec. 1922, p. 1016.
[254]Bul. Nat. Res. Coun., No. 5, 1923, p. 5.
[255]Zs. f. Physik, Mar. 5, 1923, p. 14.
[256]Phys. Rev., Dec. 1922, p. 552.
[257]Am. Jour. of Sci., Apr. 1923, p. 3141.

tion of the phosphorescent property. The yellow calcite shows a thermophosphorescence between 60° and 180°C which is destroyed by heating to about 150°C for less than 8 hours. Samples so heated until the phosphorescence had disappeared showed a strong luminescence when heated to 300–400°C. It has been found that in titanium oxide[258] the free oxide present determines the character of the luminescence produced by heat. Marked changes in color can be produced between red heat and 1200°C by a slight adjustment of the oxyhydrogen flame used in heating. Above 1200°C all excessive radiation disappears and the spectrum coincides with that of a black body both in distribution and brightness. Luminescence has been produced in chemical reactions[259] where a non-reacting compound is present. Pure oxydisilin gave a faint green luminescence when oxidized in an acid solution of $KMnO_4$. It was then treated with a solution of rhodomine B and the resulting red leaflets oxidized with acid $KMnO_4$, when an intense luminescence appeared. Isoquinoline red gave similar results.

Of a large number of compounds of the type RMgX (Grignard Reagents)[260] about thirty have been found to exhibit chemiluminescence on oxidation with $O_2$. It has been found that concentrations of the solution affect the intensity; that magnesium is a necessary constituent; slight changes in temperature have little effect; most aliphatic compounds are non-luminous while many aromatic are; changing the reacting halogen affects both the color and the intensity of the emission; the oxidation of p–$ClC_6H_4MgBr$ is said to be probably the brightest case of chemiluminescence on record; a large number of these compounds and their oxidation products are fluorescent in ultra-violet light. Additional work on p–bromophenylmagnesium bromide[261] showed the spectrum of chemiluminescence to lie within the limits 0.350$\mu$ and 0.520$\mu$. It was found to be distinct from the associated fluorescent spectra. Photographs of two kinds of fluorescence were obtained for the oxidation product of this compound.

The luminescence emitted by the vapors of benzene[262] when subjected to a Tesla discharge has a fragmentary carbon spectrum

[258]Phys. Rev., June 1923, p. 713.
[259]Naturwiss., *11*, 1923, p. 194.
[260]Phys. Rev., Feb. 1923, p. 203.
[261]Jour. Am., Chem. Soc., Feb. 1923, p. 278.
[262]Jour. of Chem. Soc., Mar. 1923, p. 642.

at ordinary pressures and the boiling point, while aniline emits a short continuous spectrum. On reducing the pressure, benzene emits a spectrum of band groups. A close relation is apparent between the Tesla-luminescence, the fluorescence, and the absorption spectra of benzene. On passing ozone through a tube electrically heated to 200°, luminescence was obtained[263] which diminished as the purity of the gas was increased. The light consisted of a band of light from about 0.460$\mu$ to 0.560$\mu$. The width of the band was independent of the concentration, pressure, temperature, and thickness of the layer observed. The light emitted was approximately proportional to the concentrations of CO and $O_3$.

Some observations on the coloration of glass by $\beta$-rays[264] indicated that the fluorescence is due to a change in the molecular aggregration of the substances. Three pieces of glass tubing were treated with radium emanation until they were colored a deep brown and ceased to fluoresce. Further treatment did not alter the color. They were then placed in an oven maintained at 110°C. They immediately began to fluoresce, and continued to do so for 13 minutes. Further heating at higher temperatures caused renewed fluorescence but for shorter and shorter periods. The results indicated that complete decoloration would occur at 500–600°C. The annealing temperature of these glasses was about 550°C. As both coloration and decoloration were accompanied by fluorescence, it seems probable that the latter was due to the change in the state of the molecular aggregations. The general fluorescent properties of cellulose and its derivatives[265] have been shown to vary with different specimens. Materials supposed to be and taken for the same by the manufacturers and the expert are by no means the same from the standpoint of their fluorescent activities. By using a brilliant reflected light[266] derived from an arc or a 400-watt incandescent lamp and a special arrangement of the cardiod dark field condenser of an ultra-microscope, the fluorescence of phycocyanin of the blue-green algae as well as a red fluorescence of the diatoms has been demonstrated. The visible fluorescence of the diatoms is confined to certain vacuoles which, by transmitted light, appear a pale greenish yellow.

[263] Ann. d. Physik, June 29, 1922, p. 527.
[264] Phil. Mag., Apr. 1923, p. 735.
[265] Jour. of Soc. Dyers Colorist, Aug. 1921, p. 201, N. P. R.
[266] Science, Aug. 3, 1923, p. 91.

Phosphorescence continues to be a subject of study and investigation.[267] Further work has been done on the decay of phosphorescence using the photoelectric light-summational method with special reference to the time measurements and to the effect of temperature. While studying the fluorescence of various substances excited by ultra-violet light,[268] it was found that the peel of the mandarin orange contains a material which fluoresces with a bright yellowish green color. The intensity is such that its spectrum can be photographed in half an hour with a direct vision spectroscope. The exciting radiation was found to be of wave-length shorter than 0.405$\mu$. When lumps of sugar are broken flashes of light appear, and this phenomenon is known as triboluminescence.[269] It was originally thought that this light had a continuous spectrum but experiments have shown that it is discontinuous and has most of the bands belonging to nitrogen but to no other spectrum. Lumps of sugar placed in a glass jar with an air pressure of from 4 down to 0.1 cm. of mercury, when shaken against the walls to break them, showed a much more intense triboluminescence than at atmospheric pressure.

*Photoelectricity*

It has been found possible to increase enormously the sensitiveness of the potassium photoelectric cell by increasing the voltage between the potassium anode and the platinum cathode.[270] For red light $\lambda = 0.630\mu$, an increase in voltage from 20 to 210 multiplied the sensitiveness by 1045 and for violet light ($\lambda = 0.462\mu$) by 1595. In order to employ such a high voltage, it was necessary to raise the potential gradually for hours or even days at a time. In forming the cell, it was found that each time the voltage was increased, there was a strong "darkness current" at first which diminished to zero for lower voltages. The relation between the photoelectric current and the illumination was found to be $I^z = ML$, where $I$ is the photoelectric current, $L$ the flow of radiant energy and $Z$ and $M$ are constants. $Z$ was found to vary with wave-length and the voltage applied to the cell. Using this cell, another determination for the exponent, $C_2$ in the Wien radiation

[267]Ann. d. Physik, Jan. 31, 1923, pp. 81, 113; Zs. f. tech. Physik, No. 2, 1923, p. 53.
[268]Jap. Jour. of Physics, **1**, No. 5, 1922.
[269]C. R., June 19, 1922, p. 1633.
[270]Zs. f. Physik, Nov. 17, 1922, p. 215.

law gave a value 14385. In this work, it was found also that carbon radiates throughout the wave-lengths investigated, which included the ultra-violet as far as 0.316$\mu$, as a gray body.

In connection with some experiments on the photoelectric theory of vision,[271] it was observed that an aqueous solution of potassium ferrocyanide exhibited a pronounced photoelectric effect when exposed to a carbon arc. Further investigation of the effect of concentration of the solution indicated that the negative radical is probably responsible for the photoelectric action and that the increase in activity of the stronger solutions is to be attributed to the effect of a possible association of the molecules of the solute. In studying the photoelectric effect in crystals,[272] it has been found that the use of single crystals considerably simplifies the phenomena. Curves showing the relation between current and field intensity of the light seem to be independent of the wave-length and of the direction of the luminous radiation. Experiments on a large number of crystals indicate that the saturation field intensity is related to the refractive index for red light. Other experiments have shown that for low voltages the potential drop near the electrodes is greater than in the middle of the crystal. The effects of crystal structure, chemical constitution and atomic weight on the spectrophotoelectric sensitivity of the chlorides, bromides, and iodides of thallium and silver and the iodide of lead have been studied. The photoelectric action of these salts was found to be confined to a narrow region of the spectrum.[273] The effect of the atomic weight is to shift the maximum of the reaction toward longer wave-lengths.

In a photoelectric cell having a tungsten filament as an anode and the usual sensitive alkaline layer for a cathode, it has been found that a much larger current will flow, when the cell is illuminated, if the tungsten filament is hot than if it is cold,[274]. Furthermore, the resistance of the cell is lower. When the filament is gradually heated, the sensitivity rises to a maximum value, after which further rise in the filament temperature results in a decrease in the sensitivity. A proposed explanation is that, when cool, the filament is coated with a thin layer of alkaline atoms which, as the

[271]Phil. Mag., May 1923, p. 895.
[272]Physik. Zs., Oct. 15, 1922, p. 417.
[273]B. of S. Sci. Paper No. 456, Nov. 8, 1922, p. 489.
[274]Phys. Rev., Feb. 1923, p. 210.

filament heats, tend to neutralize the space charge in the tube and thereby influence the photoelectric current.

The relatively low light sensitivity of selenium strips,[275] whose dark conductivity is large, can be increased about forty times by the use of very thin layers of selenium (0.5$\mu$ thickness). However, if by very careful purification of the material, the dark conductivity of the material is very considerably diminished (in some cases less than $10^{-4}$ of the ordinary), then the sensitivity to light will be found to be already high, even greater than in the case of the very thin layers, and practically independent of the layer thickness, so that the thinning produces no increase.

*Properties of Materials*

More data on the reflection coefficient of magnesium[276] has been obtained by the P. T. R. If the incandescent light is perpendicular, the reflection coefficient depends on the angle of emission. Relative values of red and green light are shown in the following table:

| Angle from the vertical | Relative Reflection Coefficients | |
|---|---|---|
| | Red | Green |
| 0° | 100 | 100 |
| 15 | 99 | 99 |
| 30 | 96 | 98 |
| 45 | 91 | 95 |
| 60 | 85 | 89 |
| 75 | 74 | 79 |
| 90 | 58 | 62 |

The diffuse reflection value for total light as obtained previously was 0.955.

By exposing rapid photographic plates[277] for an hour and a half in the ocean at a depth of 3300 feet, evidence of light was obtained, but another plate exposed at a depth of a mile showed no impression. Care was taken to avoid effects produced by luminous animals. Trials made with ultra-violet light for the sterilization of water have shown that it is operative over only a comparatively limited range of even clear water.

[275]Zs. f. Feinmech., *30*, 1922, p. 169.
[276]Zs. f. Instr., May 1922, p. 131, N. P. R.
[277]Phot. Jour. of Am., Feb. 1923, p. 79.

Further work has been done on the effect of temperature on the transmission of glasses for ultra-violet radiation.[278] A series of both crown and flint glasses in two thicknesses, 3 mm. and 6 mm., was examined using a quartz spectrograph. The range of temperature was 300° to −180° C, and the change seemed relatively small in most cases. On cooling cyanin and pinacyanol[279] from room temperature to that of liquid air, the absorption for wave-lengths in the region of 0.543$\mu$ to 0.644$\mu$ became less at the lower temperatures for the former except at 0.595$\mu$ and at the shorter wave-lengths for the latter.

It has been found that ultra-red light restores diamonds,[280] which have been altered in their properties by the action of ultra-violet light, to their original conditions more quickly than when they are kept in the dark. A considerable amount of work has been done on the effect of light on chemicals.[281]

The relations between brightness, opacity, and approximation to pure whiteness of pigments and paints have been studied with a colorimeter and cryptometer.[282] It was found that the addition of ultra-marine blue to paints containing very bright pigments which are low in blue brightness decreases their brightness somewhat but makes them far more nearly nonselective and greatly increases their hiding power. This question is of considerable importance in the case of paints used in coating Ulbricht spheres.

Much effort has been spent on trying to discover the principles underlying the action of light in discoloring pigments.[283] In the case of lithopone, experiments have indicated that the discoloration is due to the phosphorescence of the ignited zinc sulphide in the pigment caused by the presence of small quantities of foreign metals which give with the zinc sulphide colored sulphates on exposure to light. The subsequent disappearance of the color is due to the oxidation of these sulphides to the corresponding oxides. The presence of Pb, Mn, and Cu causes the pigment to become gray rapidly. Lithopone absolutely free from foreign metals showed no discoloration at all. The drying time of linseed oil and

[278]Zrch. sc. phys. et nat., Sept. 1922, p. 355.
[279]Zs. f. Physik. Chem., **100**, 1922, p. 266.
[280]Physik. Zs., Oct. 15, 1922, p. 304.
[281]Chem. Abs., Feb. 10, 1923, pp. 366, 367.
[282]Paint Mfgs. Assoc. of U. S., Circ. A 173, 1923, p. 153; Jour. of Fr. Inst., July 1923, p. 69.
[283]Jour. Soc. of Chem. Indus., Feb. 16, 1923, 150A.

varnish[284] has been found to be influenced by colored light. Films of raw linseed oil exposed to light diffused through amber, blue, red, and ground glass were dry in 14 days or less, while under green and plain glass plates they were still tacky. Those kept in the dark were as wet as at the beginning. Sunlight dried the films in two or three days. An initial exposure of a half hour to ultra-violet light was found to accelerate greatly the drying of raw linseed oil. Further experimentation is going on to determine the practical application of this work in the varnishing of automobiles.

A new field of work for the physical chemist which is being more and more explored and which in its bearing on diffusion is of importance to the illuminating engineer[285] is the molecular scattering of light in various media such as gases and vapors. Additional experiments have been performed on the scattering of light by dense vapors and gases not obeying Boyle's law.[286] For this case the results indicated that the scattering power per unit value is proportional to the square of the density of the substance and to its compressibility. A thermodynamical investigation of the scattering in liquid mixtures led to the conclusion that the light scattering arises in two distinct ways: first, to the spontaneous fluctuations in the composition of the mixture; and second, due to local fluctuations in the density. The effect of any increase in temperature on the light scattering by liquids such as benzene, methane, and naphthalene[287] has been shown by experiment to be an increase in the intensity of the scattering which passes through a high value at the critical temperature falling off again rapidly for temperatures above the critical.

*Color*

Attention should be called to an elaborate report on colorimetry[288] made by the committee on that subject to the Optical Society of America. This includes a bibliography. A new color measuring instrument[289] depends on the measurement of the reflected or transmitted light in three colors—red, green and blue. It was developed especially to identify colors in the Oswald system

[284]Paint Mfgs. Assoc. of U. S., Circ. No. 172, 1923, p. 148.
[285]Jour. of Chem. Soc., Dec. 1922, p. 2655.
[286]Phil. Mag., Jan. 1923, pp. 113, 213.
[287]Jour. of Phys. Chem., June 1923, p. 558.
[288]Jour. of Opt. Soc. of Am., Aug. 1922, p. 527.
[289]Zs. f. tech. Physik, No. 4, 1923, p. 175.

ınd measures either transparent or opaque bodies. At the bottom of an inclosed and internally blackened box are two closed and adjaent surfaces illuminated by the same light source. The illumination of one can be continuously varied. They are observed by a hotometric train, and the object to be measured is placed over ne of them. If the object is colored, the comparison is made in uccession through each of three colored glasses in the ocular of the hotometer. A color filter,[290] which is said to transmit light only etween 0.410$\mu$ and 0.570$\mu$, can be made of a saturated solution of hree parts of toluidinblau and one part of filterblaugrun. A heet 10 mm. thick of this solution reduces the light to 1/50 while 30 mm. sheet reduces it to 1/100. For sealing quartz windows to lass bulb lamps[291] such as mercury vapor or incandescent filament, has been found possible to use silver chloride and make a vacuumight joint. Silver chloride melts at 455°C, does not give off gas in ny quantity and does not decompose readily with time.

## PHYSIOLOGY

The present status of visual science[292] carried up to January 921 is discussed in a Bulletin of the National Research Council.

### *heories*

A theory of color vision which agrees with the Young-Helmoltz theory[293] as to the relative processes associated with vision as been derived from the Hering theory by assuming that the ones of the retina contain three light-sensitive substances similar visual purple—the pigment of the rods—but less stable than ıat substance. The antagonistic action of complimentary colors assumed to be produced by a nervous mechanism. Blue rather ıan yellow is assumed as a "katabolic" color. Another theory of olor vision[294] is based on the following fundamental hypothesis: rst, vision is produced by the emission of photoelectrons from a ght substance occurring in both rods and cones which shows the lective photoelectric effect; second, differences in luminosity deend on the number of electrons emitted while differences in color epend on their velocities; third, chromatic vision is possible only

[290] Physik. Berichte. Oct. 15, 1922, p. 1012.
[291] Science, Aug. 4, 1922, p. 147.
[292] Bul. of Nat. Res. Coun., Dec. 1922, Vol. 3, Pt. 2.
[293] Psych. Rev., Jan. 1923, p. 56.
[294] Jour. of Opt. Soc. of Am., Oct. 1922, p. 813.

in the cones and rhodopsin being found in the rods alone is con cerned only with achromatic vision. It acts as a sensitizer to din light and in the presence of the sensitizer, the maximum of th curve of photoelectric sensitivity is shifted to wave-length 0.53μ This theory is said to explain the main facts of color vision, after images, and color blindness reasonably well. Additional data hav been obtained on the luminous sensitivity[295] of color material i reference to the explanation of color vision.

*Eye*

An investigation made on the interpupillary distances of som 400 persons[296] gave a mean value of 63 mm. for men over 18 year of age and 61 mm. for 50 women. The data showed no definit change with age of the average interocular distances. The averag apparent diameter of the iris for all individuals tested was 12mm The pupillary reaction to wave-lengths in an equal energy spectrur at high and low intensities for the light and dark adapted eye ha been studied in man, pigeon, and alligator.[297] The curve for ma is similar to the ordinary visibility curve with a maximum at 0.554 for the high intensity and 0.534μ for the low intensity, light adapt ed eye. For low intensity of the dark adapted eye, the value wa 0.514μ. For the pigeon, the corresponding wave-lengths wer 0.564μ, 0.544μ, and 0.524μ; and for the alligator, 0.544μ, 0.514 0.504μ, and 0.514μ. The pupillary motor values are comparabl with those of rod and cone vision for radiation of high and low in tensity. The reaction time of the human pupil was found to b between 5 and 6 seconds.

Measurements of retinal sensitivity[298] in a test of 101 subjec showed individual differences far in excess of the accidental vari tions for the same individual and the same conditions. Correlatic between retinal sensitivity and a rating based upon the ophthalm portion of the Government Air Service medical examination f flying status indicates that no general relation exists betwee retinal sensitivity and disqualification. There is not much in th literature on vision [299] concerning actual experimental work which accomodation and convergence of the eye are differentiate

[295]Zs. f. Physik. Chemie, **100**, 1922, p. 537.
[296]Trans. of Opt. Soc., *23*, 1922, p. 44.
[297]Am. Jour. of Physiol., Mar. 1, 1923, p. 97.
[298]Jour. of Exper. Psych., Aug., 1922, p. 227.
[299]Ibid, June, 1923, p. 222.

Tests to determine at low intensity of illumination the accuracy of convergence as compared to that of accommodation showed the average relative error for accommodation alone to be 1/23 in contrast to 1/58 for accommodation and convergence. The illumination was 0.0117 fc. As the illumination was decreased, there was a gradual increase in error for both accomodation alone and with convergence, down to an intensity of 0.001 fc. At a point near the lower threshold for vision, accommodation alone breaks down while convergence shows little change in the gradual rate of increase of error. The results indicate further that fatigue has a greater effect on the intrinsic accommodation muscles of the eye than upon the extrinsic converging muscles.

In an investigation on the speed of retinal response[300] as a function of field brightness and light distribution, seven subjects were employed. Rather large variations in sensitivity were found and somewhat different variations with the changes in illumination and distribution of light in the visual field. The following equation expresses the results where $t$ represents the threshold time of stimulus, $B$ the brightness of the experimental field, $k$ and $B_0$ being constants depending on the individual and on other experimental conditions,

$$1/t = k \log B/B_0$$

*Vision*

The importance of binocular vision in the work of aviators and for drivers of automobiles[301] has led to an attempt to redetermine the threshold of binocular perception of distance among persons of normal vision. Three uniform threads, 0.5 mm. in diameter, having lead bobs attached to their ends, were suspended with the bobs immersed in oil. Each of the outer threads was attached to an adjustable block provided with a scale indicating the distances from the center thread. A uniform time for observation was obtained by the use of a shutter. The threshold values were found to correspond to retinal displacements of less than the diameter of one cone for all observers. A standard signal arm as used on the railroad[302] measures 10 in. x 4 ft. 9 in. and subtends an angle of 5 minutes at a distance of 1085 yards. It can be read accurately by a person of normal vision up to 1.5 miles. A test of the vision of

[300] Jour. of Exper. Psych., Apr. 1923, p. 138.
[301] Am. Jour. of Physiol., May 1, 1923, p. 561.
[302] Br. Jour. of Ophth., *6*, 1922, p. 319.

locomotive drivers, signal men, and station masters showed that a man with vision as given by the ophthalmic formula, R. 6/18, L. 6/18, both 6/12, can with both eyes open read these signals accurately at 1500 yards and that, provided vision with both eyes open is not below 6/12, color perception is not dangerously lowered.

Caused by a desire to know why a greater intensity of natural lighting than of artificial lighting seems to be required for the same kind of work, [303], additional comparative data have been obtained on the intensities desirable for reading using both the direct and indirect lighting systems. The room used for the experiments was 30 ft. x 18.5 ft. and 13 ft. high with a ceiling and upper half walls white, lower half and floor drab. The work was done at night. For direct lighting, opaque white enamel reflectors were used, placed 7.5 feet above the floor. For the indirect lighting, opaque bowl and silver reflectors were used and hung 2 feet below the ceiling. Current through the lamps was adjusted so that the illumination was approximately the same for either system. Five different values of the current were used to produce variations in illumination from one which was just too low for comfortable reading to one which was just too high. Twenty-six observers took the test and recorded their impressions. The results showed that an average of 2.8 fc. was considered "just right" under the direct illumination while 4 fc. were required under the indirect. The result was attributed to the effect of the greater equality of distributed illumination in the field of view under the indirect system, causing pupillary contraction and requiring a higher intensity for comfortable reading. This condition was considered to be similar to the conditions occurring in the use of natural lighting.

Another determination of the visibility curve[304] by the "step by step" equality-of-brightness method has been made between the wave-lengths 0.430$\mu$ and 0.740$\mu$, using 52 observers of which number, 14 made measurements between 0.49$\mu$ and 0.68$\mu$ only. Luminosity values were obtained with a Brace spectrophotometer by moving the collimator slit. The results were somewhat higher in the extreme blue and red[305] than those previously obtained by

[303] Elec. World, Dec. 9, 1922, p. 1268.
[304] Jour. of Opt. Soc. of Am., Jan. 1923, p. 68.
[305] Jour. of Wash. Acad. of Sci., Mar. 4, 1923, p. 88.

this method, but they still indicate a real difference between the data obtained by this method and those obtained by the flicker method.

*Visual Acuity*

It has been shown that a reduction of the visual acuity[306] is always followed by an apparent diminution in size and at the same time the removing and bringing nearer together of the objects observed. On the other hand, a sudden increase in visual acuity produces an apparent increase in size. A proposed explanation is based on the assumption that maximum impulses to accommodate are liberated in such a manner that the distinctness of the image is not blurred when the conditions of the formation of the image are altered. An elaborate analysis has been made of the physiological limits to the accuracy of visual observations and measurements, using data and information already available and a form of field suggested[307] for instruments used in measuring color and intensity permitting of a higher degree of accuracy than has been heretofore possible.

*Color*

An experimental method of evaluating the spectral colors[308] in terms of the three primary colors as used in the color triangle has been worked out. The values obtained gave wave-lengths 0.675 up to $0.5625\mu$ in a straight line and wave-lengths $0.530$ to $0.430\mu$ on another line, the two forming sides of the triangle. The color of the vacuum tungsten lamp as given by this triangle was found to be 19.6 red, 30.1 green and 50.3 blue. Daylight from a north sky was 8 red, 20 green and 72 blue.

The situation and extent of the region of the spectrum which is yellow[309] has been determined by 12 men and 12 women, all accustomed to judge colors. The extent and position of the yellow zone was found to vary from individual to individual. For one person, it lay at $0.577-0.583\mu$; for another at $0.583-0.585\mu$; and for a third at $0.5875-0.590\mu$. For the twenty-four persons, no radiation was conceived as pure yellow beyond the limits of $0.596\mu$ at one end and $0.574\mu$ at the other. The extent of the spectrum

[306] Jour. of Opt. Soc. of Am., Aug. 1922, p. 597.
[307] Phil. Mag., July 1923, p. 49.
[308] Ibid, Jan. 1923. p. 169.
[309] Jour. of Physiol., Mar. 21, 1923, p. 181.

varied between 0.001$\mu$ and 0.012$\mu$ and was on the average less fo the women than for the men. The results indicated that no mono chromatic light exists which gives the impression of being yellow t normal eyes when adapted to a weak (1 m. lux) neutral illumina tion and the radiations exposed are not chosen stronger than i necessary to render possible the distinguishing of colors. It ha been quite common practice[310] to take 0.4$\mu$ as the dividing lin between the visible radiation and the ultra-violet. Observation (by one observer) to determine this point have confirmed th practicability of using this wave-length, although shorter wave lengths were seen, since there was a very marked drop in sensitivity for light below 0.4$\mu$.

As a result of experiments on the selectiveness of the eye' chromatic response to wave-length[311] and its change with change i intensity, it has been concluded that at the threshold the eye i most sensitive to green, yellow-green, blue, blue-green, yellow, red and orange in the order named, with a dark surrounding field; with a light surrounding field, the order changed to blue-green, green blue, yellow-green, red, yellow, and orange. At the point of maxi mum saturation with a dark surrounding field, the eye was mos sensitive to yellow-green, then to green, orange, blue, blue-green red, and yellow; and with light surrounding field, to the yellow green, green, orange, blue-green, blue, red, and yellow.

An investigation to determine whether the selection and combi nation of colors according to the Munsell system[312] is in accord with the actual preference of various classes of persons was carried ou with 18 business men, 15 graduate men students, 25 women (no students), and 25 commercial artists. The relative agreement o the colors in five sets of colored papers was first determined an then the colors and their combinations were analysed according t the Munsell notation. The results showed that complimentary color combinations were most highly preferred with some excep tions; that the commercial artists agreed no more closely among themselves than did the persons in the other groups; and that th preferences of the commercial artists did not agree so closely with the preferences of non-artists as varying groups of the latter agreed with one another.

[310]Am. Jour. of Physiol. Opt., Apr. 1923, p. 145.
[311]Jour. of Exper. Psych., Oct. 1922, p. 347.
[312]Psych. Bul., Feb. 1923, p. 85.

What factors influence an individual in deciding that a light is gray and what constitutes a normal gray? In order to answer these questions, experiments have been performed[313] on the effect of field size and shape, brightness, exposure, duration of dark adaptation, and order of presentation of stimuli. The stimuli employed were obtained by filtering the light of an incandescent lamp through color-matching glass. The results showed that the stimulus of gray as determined by the method used is independent of the first four conditions. The first few stimuli presented as short exposures after long dark adaptation will momentarily be called yellow, even though they would be called gray or blue on long exposures. If the stimuli are presented in increasing or decreasing order of color temperature and in rapid succession, the result depend on the order of presentation.

It has been known for years that, at low intensities of illumination, the visible spectrum, as viewed by a dark adapted eye, appears colorless. A new set of data have been obtained[314] on the relative energy necessary in the different parts of the spectrum in order to produce a colorless sensation in the eye. It was found that the curve representing the visibility of the spectrum at very low intensities has exactly the same shape as that for high intensities involving color vision but is shifted a distance of $0.048\mu$ toward the red. A proposed possible explanation is that the same substance, i.e. visual purple, whose absorption maximum in water solution is at $0.503\mu$, is dissolved in the rods, where its absorption maximum is at $0.511\mu$, and in the cones, where its maximum is at $0.554\mu$. Tests for color blindness of 547 students by the Raleigh method[315] showed no abnormality of color vision among the women and only 14 among the men, who were very or partially abnormal.

An investigation of the effect of fatigue in one eye on the perception of color by the other[316] resulted in the discovery that each color of the spectrum produced a reflex effect which affected three points—red, violet, and greenish yellow. Each reflex curve has three deflections below normal. In this case, the left eye was fatigued and measurements of critical frequencies of flicker were made with the right eye which was kept in daylight adaptation.

[313] Jour. of Opt. Soc. of Am., Jan. 1923, p. 73.
[314] Jour. of Gen. Physiol., Sept. 20, 1922, p. 1.
[315] Proc. Royal Soc. (A), Dec. 1, 1922, p. 353.
[316] Jour. of Opt. Soc. of Am., Jan. 1923, p. 61.

Experiments were also made with the right eye fatigued. Both sets of data indicated that every ray of color stimulated all three sensations by reflex action, thereby causing a sensation of whiteness underlying and inseparable from color.

*Action of Light*

A great deal of attention has been given to the action of radiation,[317] both visual and ultra-violet, on plants and animals, not only for the purpose of increasing general scientific knowledge but also from a therapeutic and prophylactic standpoint. The action of ultra-violet light on egg white[318] has been studied for colloidal solutions of globulin, albumin and fibrinogen. The experiments showed an increased coagulation temperature and a reaction toward alcohol. Viscosity increased in proportion to the duration of irradiation.

The movement of animals when exposed to light (phototropism) has been shown to be due in the case of the lowest forms (Amoeba)[319] to inhibition of movement toward the more highly illuminated side. In other unicellular forms, there are primitive receptors which serve to produce in unoriented species rapid changes in luminous intensity on the sensitive tissue side. In the flat worms, the receptors (eyes) are of such a nature that illumination from different directions results in different locations of the stimuli, each of which produces special series of orienting reactions. The action of the salt water king crab (Limulus),[320] when exposed to light under laboratory conditions, is plus phototropic. The phototropism may be modified or obliterated by fright, hunger, stereotropism, photokinesis and other unknown stimuli. The rate of locomotion varies directly as the luminous intensity, being 178 cm. per minute for an illumination of 8,000 m.c. and 157 cm. for 900 m.c. These reactions are said to be satisfactorily explained by the tropism theory. Snail embryos have been found to present a wide range of individual resistance to the action of ultra-violet light.[321] Resistance increases with advancing age. A study has been made of the effect of intermittent light on the tachina fly[322] which is usually highly

[317] Physiol. Abs., Apr. 1923, p. 72.
[318] Pflüger's Archiv, Nov. 11, 1922, p. 540.
[319] Jour. of Opt. Soc. of Am., Jan. 1923, p. 61.
[320] Jour. of Gen. Physiol., Mar. 20, 1923, p. 417.
[321] Jour. of Exper. Zool., Jan. 5, 1923, p. 1.
[322] Am. Jour. of Physiol., Apr. 1, 1923, p. 364.

phototropic. When exposed to continuous light from two sources, the rays of which cross at right angles, the flies were found to move toward a point between the sources, the location of the point depending upon the relation between the illuminations received. With an illumination of 35 m.c., the stimulating efficiency of intermittent light in the orientation of this fly varies with the flash frequency. At flash frequencies from 50 down to 10 per second, the stimulating efficiency was higher than that for continuous light, the maximum being at 15 per second. At a flash frequency of 2 per second, it was lower than that of continuous light and at frequencies of 5, 60, and 160 per second, approximately equal to that of the steady light.

Investigations of the absorption of ultra-violet radiation by living tissues,[323] some physiological solutions and some spectral glasses, showed that in the case of the glasses, flint is more effective than crown. In the case of the tissues of the eye, the lens is the most effective screen and next to it, the cornea. The data on eye absorption have been verified[324] by another investigator who found that the combined tissues of the eye absorbed ultra-violet radiations up to about 0.3134$\mu$ and that formalin changes the absorption. The eyes used in the latter experiments included four human eyes, and others taken from cows, pigs and sheep.

## ILLUMINATING ENGINEERING

### *Daylight Saving*

In spite of the protest of the rural population[325] Great Britain again went on daylight saving time, April 22, 1923 to continue until September 16. In France[326] a compromise was effected by changing the basis of time comparisons from Paris to Strasbourg, which had the effect of advancing the clocks a half hour the year round. Until ten years ago Greenwich time was used in France, but at that date a shift was made to Paris time which advanced the clocks at least ten minutes.

Daylight saving time was adopted in Niagara Falls, Ontario[327] over vigourous opposition, but was dropped in Baltimore, Maryland.[328]

[323] Australian Med. Jour., Sept. 2, 1922.
[324] Jour. of Opt. Soc. of Am., Aug. 1922, p. 605.
[325] Gas Jour., Mar. 28, 1923, p. 818.
[326] Clev. Plain Dealer Sunday Apr. 29, 1923.
[327] Mov. Pic. World, May 5, 1923, p. 39.
[328] Ibid, May 12, 1923, p. 116.

*Light Sources*

The relatively low efficiency of artificial light sources compared with the relatively high efficiency of luminous organisms such as the firefly has emphasized the importance of these organisms as sources of light production. Those interested in this subject should look up an elaborate review[329] of recent literature which contains a bibliography.

The problem of how the firefly and other luminous organisms produce their light is progressing toward a solution.[330] It has already been shown that the light-producing reaction is one involving the oxidation of a substance called luciferin in the presence of a thermolabile material called luciferase, which apparently acts as a catalyst, and is necessary for light emission. The oxidation product, oxyluciferin has now been shown to be reducible to luciferin by the passage of an electric current through the solution. It may also be reduced at cathodes of oxidation-reduction cells of the NaCl-Pt-Pt-$Na_2S$ type, and also at metal surfaces such as Al, Mn, Zn and Cd which liberate nascent hydrogen from water. A method of producing continuous luminescence is suggested, using a slow stream of hydrogen and oxygen. A large palladiumized surface would continually reduce oxyluciferin which would just as continuously reoxidize in the presence of luciferas and oxygen. Thus a continuously operated luminous lamp could be made. It is suggested that the steady luminescence of bacteria may be due to the continuous oxidation of luciferin and reduction of oxyluciferin in different parts of the bacterial cell.

Further work on the minimum concentration of luciferin,[331] which is visible, has shown that one portion in from 4 to 40 billion parts of sea water gives on oxidation light visible to the unaided but dark adapted eye. A similar experiment with luciferin showed that one part in from 800 million to 8 billion parts of sea water will oxidise a stock solution of luciferin with visible luminescense.

A report to the Smithsonian Institution[332] of explorations in the wilds of Costa Rica describes a type of beetle which is said to emit almost without interruption a light so brilliant that one or two im-

[329]Erge. der Physiologie *21*, 1923, p. 166.
[330]Jour. of Gen. Physiol., Jan. 20, 1923, p. 275.
[331]Science, Apr. 27, 1923, p. 501.
[332]Sci. News Letter, July 28, 1923, p. 10.

prisoned in an inverted tumbler will illuminate a moderate sized room sufficiently to make print readable. The beetles are called "carbuncles" and the light differs in color in different individuals, being mostly yellow but sometimes green and occasionally ruby red.

A practical application of the idea that insects are more attracted to violet and blue light than to red or white light[333] has been reported from a western city. Electric globes colored a light red have been used in lunch rooms, dancing pavillions, bathing beaches, country club houses, and street cars with a resulting freedom from insects, the number of which previously had been very annoying.

A study of the causes of fouling ships' bottoms[334] has indicated that color is an important factor. Barnacles, especially, seem averse to light colors. In general, the fouling was found to be greater on dark than on light painted bottoms, the difference between white and black paint being especially marked.

*Photography*

The high luminous intensity when a wire filament is exploded by the application of a high potential[335] has inspired the development of a new light source for instantaneous photography. Experiments with tin and copper wires not being fruitful, mercury was successfully substituted. The mercury filaments were made by drawing mercury into a glass capillary tube each end of which contained a hair wire electrode sealed in with sealing wax. With lengths of 10 mm and diameters ranging from 0.172 to 0.324 mm. and an applied voltage of 80, the duration of the flash ranged from less than $10^{-5}$ seconds with a very feeble light to $8.0 \times 10^{-4}$ seconds with a very bright flash. The duration was found to depend on the diameter and length of the filament and on the thickness and wall of the capillary.

In connection with photomicrographic work the ratio of actinic or chemical surface brightnesses[336] of various light sources has been worked out as well as an apparatus and method for determining the absolute brightness in terms of the Hefner. The absolute properties of mat reflective surfaces used in this work have also been studied.

[333] Scien. American, Mar. 1923, p. 179.
[334] Pop. Mech., May, 1923, p. 769.
[335] Jap. Jour. of Phys. *I*, No. 9, 1923, p. 97.
[336] Zeit. f. Instr., Dec., 1922, p. 349.

*Legislation*

Attention should be called to references in the notes and abstract portions of several issues of the Transactions on legislation involving lighting in various states. In Wisconsin[337] the new state electric code which went into effect the first of the year provides that, "gas-filled incandescent lamps of more than 100-watt size cannot be used in the common type of socket having paper linings." Special sockets of porcelain are required. The load allowed to branch sockets is increased to 1000 watts provided that fuses not heavier than 15 amperes are in the circuit. The Rhode Island Legislature[338] has passed an act apparently especially directed toward the City of Providence, providing that, "In all theatres . . . ordinarily lighted by electricity there shall be in addition . . . an independent means of light which shall be (either) gas from a commercial gas distribution system (or) a storage battery system controlled either automatically or from . . . the lobby or front of the theater, or such other system or means of lighting as shall be approved by the City Council of Providence. In case such lighting system shall be gas, at least two lights on each side of the main body of the theater and on each side of all balconys, as well as a sufficient number of additional lights to illuminate the stairways, hallways, and lobbies shall be kept burning at all times when such theater is open to the public."

In the Annual Report of the Chief Inspector of Factories and Workshops of Great Britain,[339] an account is given of improved lighting conditions on docks and wharfs where cluster lamps have been found to be satisfactory. In South London, the report states, "It is unusual to find an entirely satisfactory system of lighting." In 78% of the underground workrooms visited, the natural lighting was insufficient to illuminate the whole room. However, there is some evidence of increased attention being paid to correct methods of illumination. Several cases of lighting by the indirect system are noted including a lithograph factory, plating works, and a tobacco works.

[337]Elec. Rec., Jan., 1923, p. 5.

[338]Gas. Jour., Dec. 6, 1922, p. 636.

[339]Elec., Aug. 4, 1922, p. 122.

*Plants*

The problem of photosynthesis or the action of sunlight on the green leaves of plants[340] to produce sugar, starch and wood out of carbon and carbon-dioxide was discussed at a joint meeting of chemists and botanists at the Boston meeting of the A. A. A. S. A proposed explanation is that the first step in the process is the breaking down of the carbonhydrogen molecule into a very large number of enormously reactive substances. These substances either rearrange and react with each other or with some other substance in the cell, possibly with $CO_2$. Experiments on the growth of plants under artificial light[341] from seed to seed have been reported as successful. Wheat, oats, barley, rye, buckwheat, potatoes, and several vegetables growing from seed, under artificial illumination only, produced seed of good quality which germinated well. The illumination was obtained from tungsten filament incandescent lamps burning 24 hours a day. One set of lamps was said to be enough to produce an ordinary crop, such as cereals. Spring wheat produced ripe seed in about 90 days. All the plants tested, except cabbage, bloomed and no variety seemed to require any particular period of illumination to cause blooming. Four ranges of light intensity were used, and a number of plants bloomed under all of them although the illumination was continuous. The temperature was maintained automatically for cereals at 14° C, by blowing in outside air.

The increased velocity of germination of seeds[342] when exposed to moonlight was indicated by some experiments in which the effect was thought to be due to the action of the moonlight on diastase. A test of the latter point, using crushed mustard seed showed a 15 per cent increase in sugar yield over seed not exposed. At certain periods moonlight is plane polarized and a similar set of experiments on the seed, using polarized daylight gave similar results. Care was taken in this work to have the temperature conditions the same for exposed and unexposed packages of seed. The experiments are being continued.

The stimulation of plant growth[343] by artificial light has been tried in Germany. Over a plot of lettuces 5 lamps were arranged

[340]Sci. News Letter, Jan. 13, 1923, p. 8.
[341]Science, Sept., 29, 1922, p. 366.
[342]Nature, Jan. 13, 1923, p. 49.
[343]Elec. Rev., Mar. 30, 1923, p. 511.

so that the light was diffused as uniformly as possible. The lamps were turned on for six hours each day beginning at dusk. Cabbage-lettuces illuminated from the middle of November had after 12 days about two and a half times as many fresh leaves as those not illuminated. After seven weeks of prolonged illumination a comparison made between the plants on the illuminated plot and those on the plot not illuminated showed a 50 per cent superiority in weight of the former over the latter in the green state and 68 per cent in the dried state. The effect was equally good with beans and vetches. Illuminated strawberry plants yielded as early as the middle of March as compared to four weeks later for non-illuminated fruits.

*Societies*

In the plan for the future as laid out by the British Illuminating Engineering Society[344] it is proposed to organize extensive propaganda with a view to interesting municipal bodies, educational authorities, owners of workshops and factories, etc., in illumination; arrange lecture demonstrations in various parts of the country for the benefit both of those technically concerned with lighting (architects, contractors, etc.,) and improved classes of consumers; form a fund for researches and especially aid experiments to be conducted by the various committees of the Society; expand the size of the Journal by including special contributions on selected subjects; initiate propaganda in the Colonies and Dominions. This program indicates that much of the work of our Society has met with the approval of our neighbors who are incorporating it in their plans.

A joint committee has been set up by the British Commercial Gas Association and the Society of British Gas Industries[345] to consider matters affecting gas lighting. Among other points for consideration are the standardization of the essential parts of the burner; the elimination of shoddy burners, mantles, and fittings; the maintainance and development of gas lighting.

The French National Committee on Illumination[346] met last November. Among other subjects discussed was the question of making a bibliography of all the work connected with lighting. A

[344]Ill. Eng., July 1922, p. 218.
[345]Gas. Jour., Nov. 1, 1922, p. 286.
[346]Rev. Gen. d'Elec., Dec. 9, 1922, p. 873.

meeting of the Sub-Committee on Automobile Headlights[347] was held on March 21, this year, and took up the question of the French codes on this subject. A report of the English National Committee was referred to in the July 1923 issue of the TRANSACTIONS of this Society.

At the Tenth Annual Convention of the German Illuminating Engineering Society[348] the program included among others the following subjects: "Our present conception of the nature of light"; "Illuminating engineering lectures and papers"; "The present and future of gas lighting"; "Impressions of a course of study on illuminating engineering in the United States of America".

The Advisory Board of the Engineering Foundation[349] has received and is thoroughly investigating the feasibility, cost, and probability of support of a suggested experimental investigation of the relation of quality and quantity of illumination to efficiency. It is felt that the determination of this relationship by disinterested parties will be very valuable in industry.

*General*

The largest telescope in the world, the 100 inch reflector at Mount Wilson Observatory[350] collects 160,000 times the light received by the eye.

The photo-electric cell is one of the numerous illustrations[351] of the possibility of research work having direct practical application. Means of applying the cell, either of the selemium, alkali metal, or thalofide type, to the control of industrial processes have been proposed and specific cases worked out. The general method is to produce such a change in the intensity of illumination of the cell as to produce a corresponding change in the current sufficient to operate a relay which in turn controls the proper valves, switches or other means necessary to effect the desired reaction. Among the optical properties suggested for use are absorption power for white light, selective absorption power, index of refraction, and rotation of polarized light.

[347]Ibid, May 12, 1923, p. 769.
[348]L. u. L. Sept., 21, 1922, —. 443 and Oct., 5, p. 463. Zeit. f. Bel. Sept. 15, 1922, p. 121.,
[349]Report of Engineering Foundation, Apr., 1923, p. 23.
[350]Sci. News Letter, Dec., 9, 1922, p. 8.
[351]Jour. Soc. Chem. Indus., Feb., 16, 1923, p. 127A.

The detection between ordinary artificial pearls and natura pearls[352] can be made by mechanical means, but the Japanes cultivated pearl has defied such detection except by destruction until recently. Under the light from a mercury vapor lamp th Japanese pearl shows a distinct translucent opalescence, while th natural pearl, though opalescent is opaque. This distinction i evident even to a layman.

The meteorological service of the city of Paris[353] has conducte experiments on the effect of smoke in causing loss of light in th city and suburbs. The total actinometer or lucimeter of Bellar was employed to make the measurements. Observations wer made on eight stations and the quantity of light received in 2 hours was determined at each one and compared with that whic should be received. It was found that where the wind was suc that the smoke from the city was blowing over the suburb the los of light was as much as 25 per cent.

The Institute of Technology at Carlsruhe[354] inaugurated it school of light in June 1922. This department has four room darkened and provided with photometric equipment. The firs has three photometer benches, 3 m., 4 m., and 4.8 m. long respec tively as well as an Ulbricht sphere. The other rooms have ar rangements to extend the length of the photometer benches, an one has a Rousseau photometer as well as other equipment to meas ure illumination and distribution. A fifth room is equipped with number sockets to try out different lighting units. A number o rooms are provided for special work such as that of physiology o the eye, glare, influence of diffusion, etc. The equipment include two sets of storage batteries which provide the electric current. Th buildings and observation tower will permit the photometric an physical study of light from the sky.

## JOURNALS AND BOOKS

The American Builders Magazine has started a department[355] in which, in addition to other information, will be given informa tion for wiring luminaires, and arrangements and suggestions fc decorative lighting.

[352]Sci. Amer., Apr., 1923, p. 227 and Chem. News., Aug., 11, 1922.
[353]Comp. Rendu., Jan. 15, 1923, p. 180.
[354]Rev. Gen. d'Elec., Jan. 20 1923, p. 24D.
[355]Elec. World, Feb., 24, 1923, p. 472.

The Germany Illuminating Engineering Society[356] has designated the technical journal "Licht und Lampe" as the official organ for the publication of its proceedings, in the place of the Zeitschrift fur Beleuchtungswesen which owing to economic conditions has been compelled to suspend issue. Dr. Lux, the former editor of the Zeitschrift fur Beleuchtungswesen will continue to edit the Society's work as presented in Licht und Lampe.

*Books*

"Colour Vision," Prof. W. Peddie, (London: E. Arnold & Co., 1922). Pp. xii + 208. See "Nature," June 16, 1923, p. 799.

"Colour and Methods of Colour Reproduction," Dr. L. C. Martin, William Gamble, (London, Glasgow and Bombay: Blackie & Sons, Ltd., 1923). Pp. xiii + 187. See "Nature," June 16, 1923, p. 799.

"L'Eclairage," E. Darmois, (Paris: Gauthier-Villars & Cie, 1923). Pp. xv + 276.

"The Elementary Principles of Lighting and Photometry," W. T. Walsh, (London: Methuen & Co., Ltd., 1923). Pp. xvi + 220. See "Nature," June 16, 1923, p. 804.

"L'Arc Electrique," Maurice Leblanc fils, (Paris, Les Presses Universitaires de France, 1922). Pp. 131. See "Nature," June 16, 1923, p. 805.

"L'Eclairage et le Demarrage electriques des Automobiles," J. Bardin, (Desforges: Paris, 1922). Pp. 64.

"Die Fabrikation und Berechnung der Modernen Metalldrahtglühlampen," F. Knepper, (Leipzig: Hachmeister & Thal, 1922). See "Helios," Sept. 3, 1922, p. 428.

"Heliotherapy," Dr. A. Rollier, (London: Oxford Medical Publications, Henry Frowde & Hodder & Stoughton, 1923). p. 288.

"Die Heterochrome Photometrie in Theorie und Praxis," R. von Voss, (Julius Springer: Berlin, 1919).

"Incandescent Lighting," S. I. Levy, (London: Sir Isaac Putman & Sons, Ltd., 1922). Pp. 124. See "Gas Journal," Dec. 20, 1922, p. 734.

"Lamp Shades—How to Make Them," Olive Earle, (Dodd, Mead & Co.).

[356] L. u. L., Nov., 1922. p. 483.

"Motion Picture Projection," J. Slater, (London: The Bi scope Pub. Co., Ltd.) Pp. 165.

"The Romance of the Gas Industry," O. E. Norman, (Chicag A. C. McClurg & Co.) Pp. 200; illus., 51.

"Die Stereoskopie im Dienste der Isochromen und Heterochr men Photometrie," C. Pulfrich, (Berlin: Julius Springer, 1922).

"Visual Illusions, Their Causes, Characteristics and Applic tions," M. Luckiesh, (New York: D. Van Nostrand Co., 192 Pp. 246 + xv. Ill. 100.

"Ultraviolet Radiation," M. Luckiesh, (New York: D. V Nostrand Co., 1922). Pp. 247 + xiv. Ill. 12.

"The Book of the Sky," M. Luckiesh, (New York: E. P. Du ton & Co., 1922). Pp. 236 + xi. Ill. 16.

"Light and Color in Advertising and Merchandising," M. Luc iesh, (New York: D. Van Nostrand Co., 1923). Pp. 263 + Ill. 37.

# LIGHTING THE SILK INDUSTRY WITH INCANDESCENT LAMPS*

BY H. W. DESAIX**

SYNOPSIS: This paper is based on observations, investigations and experiments conducted by the author to secure for the Silk Industry a practical system of illumination to replace the present inadequate and impractical methods.

Each process in the manufacture of silk fabrics presents a problem in itself and each has been so treated.

Owing to the paper being prepared for an audience of laymen technical terms and expressions were purposely omitted where possible.

During the early months of this year a survey was made of various silk manufacturing plants for the purpose of obtaining data for the better lighting of plants in this industry. This survey was later supplemented by experimental installations from which tests and further observations were made, eventually leading up to some very gratifying results.

As the idea seems to suggest itself, this presentation is in the nature of a report of this investigation. Time, however, will not permit of detailed data being given for each step in the process of manufacturing silk fabrics, but what appears to be the most important will be dealt with.

An inspection revealed most of the plants using pendant drop cords, hung about two feet over the working plane of looms and a trifle higher over accessory machines. In some instances bare 50- and 60-watt Mazda lamps were in use; but in the majority tin cone or flat shaped painted reflectors were in use. This latter system seems to be the conventional means of lighting silk weaving plants.

*A paper presented before the joint meeting of the New York Section and the Northern New Jersey Chapter of the Illuminating Engineering Society, Patterson, N. J., May 11, 1923.

**Watson-Flagg Engineering Company, Paterson, N. J.

WEAVING

In some weaving plants, drop cords were in use being ever with the bottom of the arch of the loom using bowl type, enameled steel reflectors, with 50- and 60-watt type "B" Mazda lamps, and in some instances mill type lamps. This latter system is unquestionably an improvement over those mentioned above. It has its faults, however, being expensive in comparison to the result obtained; lamps do not as a rule burn their natural life, due to constant handling, striking of reflectors against loom arch: and because of theft. There is also a tendency on the part of operators to install larger lamps in the sockets, with the well-known result glare. Another fault of the local lighting system for weaving, and in fact other processes, is eye strain of operators due to the constant change of looking into comparative darkness as compared with the light on the warp.

Illuminating engineers, heretofore, have recommended a general lighting system to supplement the local to overcome the last objection and to provide proper lighting for aisles. This has always seemed to the mill executives a duplication of system and extra avoidable expense; very often it resulted in an unpopular lighting engineer.

On the other hand, general lighting systems in weave sheds have been attempted but have proven unsatisfactory because objectionable shadows were cast by loom arches, and an insufficient amount of light in between the heddles at which point ends must at times be picked up and passed thru.

Conferences with mill executives, weaving foremen and operators themselves, led to the opinion that if a system of illumination could be worked out that would incorporate the advantages of the concentrated result of the improved local system, and the further advantages of the usual general system, at a reasonable cost of installation and upkeep, consistent with the desired result, it would fill a long felt want and at once become popular. With this idea in mind, experiments and tests were started.

For the purpose, a room was used containing 24 plain broad silk looms, arranged in 4 rows across, a wide aisle in center, with 6 looms to a row. The room was typical of most that are used for the purpose, the ceiling was of open wood beam construction, with walls and ceiling painted white, except for a distance 4 feet up from

he floor where the walls were painted light grey. It was located n the ground floor necessitating the use of artificial light all day.

The lighting system in use was the customary drop cord with in cone shaped painted reflectors, and 50-watt mill type Madza amps. Test showed this system as delivering an average of 11 oot-candles on the warp, but with the undesirable effects out- ned above.

In order to be satisfied that previous opinions were well ounded a general system was next installed employing RLM ome steel enameled reflectors, with 200-watt "C" bowl enameled Iazda lamps, spaced on centers over each loom station or weavers lley; this spacing meant 13′3″ between units along the rows and ′0″ across and 10′0″ between rows on each side of center aisle. Iounting height 12′0″ from floor or approximately 9′0″ above orking plane. Uniform average intensity of 10 foot-candles was ecured.

From general appearances this system seemed to be quite tisfactory. It certainly eliminated all the objections of the local stem; but while sufficient light was delivered for general purposes ere was not enough to see to pass ends through the heddles in e harness. Shadows were encountered from the loom arches d by the operators when leaning over the work. This system also iled to provide an upward component to enable the transmission quipment, such as shafting, hangers and pulleys to be adjusted.

An analysis was then made of the above systems, the obstacles be overcome and the nature of the work done in a weaving ant; from this it was concluded that the system desired must ntain the following factors:

A varied intensity of illumination. With a higher intensity on the looms as compared with drives and aisles.

Adequate intensity for all purposes.

Freedom from objectionable shadows.

Freedom from glare, both direct and by contrast.

Must provide sufficient light on walls with a well distributed upward component, in order to have interior or room give a bright cheerful appearance.

The cost of installation and upkeep must be reasonable in comparison to result and must pay a return on the investment.

Uusually the required intensity is known, but in this case th value in use did not appear sufficient, making it necessary to wor the reverse of regular practice; i.e.—effect to cause.

After a thorough study of the various types of luminaire th market afforded one was selected. This unit consisted of a rugge prismatic glass reflector 11⅞″ in diameter and 5⅞″ in height open top and bottom. The distribution curve showed it to be c the intensive type, with sharp cut off at 60° from the vertica falling away sharply after 15°. Supported by a three prong holde designed on the ice tong principle which grips the lower flange c the reflector. An adjustable stem is provided with marked cali brations for 75- 100- 150- and 200-watt lamps; it made an ideal uni for the purpose of the test. These units were hung on the sam spacings and mounting heights as were the RLM reflectors use in the previous experiment.

With 200-watt type "C" clear Mazda lamps, readings wer taken of 30 foot-candles on the warp tapering to 15 foot-candle in the aisles and on the drives, which satisfied the first requiremen of varied intensity or "spilled" light. See Figure 1.

The amount of light was entirely sufficient; in fact, at first wa considered too high, but later experiments disproved this. Ente ing ends thru harness could be done with ease and plenty of light Arch and operators shadows were not at all objectionable becaus of high intensity.

With practically the entire ceiling moderately illuminate glare by contrast was not encountered as the tunnel-like appea ance was illuminated; and transmission equipment could be oile and adjusted easily. This excellent upward component is ver desirable for the sake of its cheerful appearance, especially wher women are employed, as in this industry. Because the light cut o occurs at 60° direct glare was practically nil.

Quite naturally, certain objections were raised, such as th possibility of glass breakage, but this was not considered serious because the units were hung at a height from the floor which re moved them from the sphere of activity and being of rugge construction would require a hard blow to cause breakage.

Another objection was the collection of dirt or dust, but it wa pointed out that if dust did collect on top to any extent the con dition could not be any different than that of an opaque reflecto

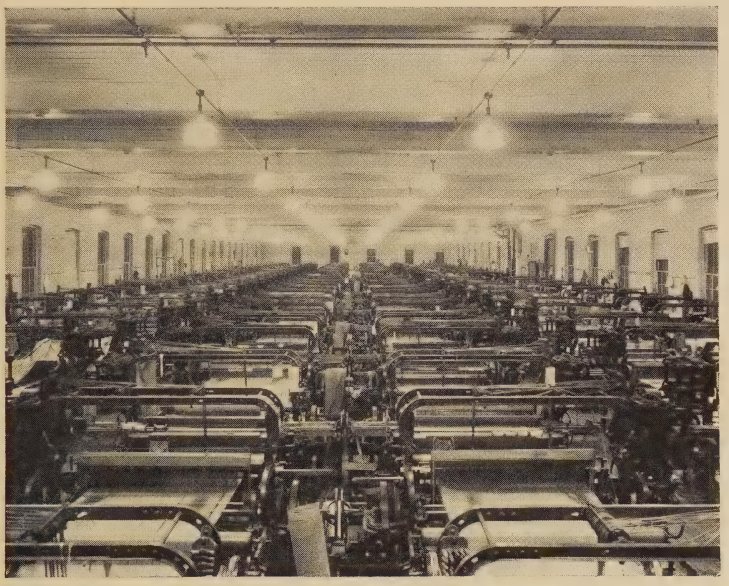

FIG. 1—Unobjectionable varied intensity, no confusing shadows, and well lighted interior in a weave shed. Illustrates "spilled" lighting principle.

FIG. 2—Winding and Quilling room lighted at 12 foot-candles, using prismatic glass reflectors spaced 12 x 12 feet.

FIG. 3—Night photograph of dye house. Vapor proof units spaced 10 x 10 feet with 150-watt Mazda C lamps, resulted in intensity of 12 foot-candles with equal distribution on vertical as well as horizontal surfaces.

The fact that dirt might collect would have a tendency to induce shorter periods between cleanings. Being designed with reflecting prisms, dirt or dust does not impair reflecting efficiency unless mixed with oil as the oil excludes the air film which normally prevents optical contact. In fact, dust and dirt is something which should not exist to any great extent in a silk weaving plant.

The results obtained were well worth the effort expended, as it was the unanimous opinion that a system of illumination had been worked out that fullfilled all the necessary requirements of silk weaving.

Later this system was installed in the entire plant which made it possible to determine costs. It was found that the cost of installation, using a modern conduit wiring system with convenient switching arrangement equalled one-half a cent per foot-candle per square foot.

### WINDING AND QUILLING

When winding, the broken ends are detected by the stopping of the swifts, and in quilling are detected by the raising of the quides, making it very easy to detect broken ends or spent spools from any position in the aisle. For these operations RLM dome steel reflectors with 200-watt Madza "C" lamps spaced on 12 ft. centers hung 12 ft. high will give a general illumination of about 8 ft. candles. An intensity sufficiently high for ordinary purposes.

It has been found advisable in some instances that a higher intensity is required for which the same equipment is recommended as for weaving, spaced at a distance not to exceed mounting height which will deliver a general intensity of 12 foot-candles and also provide a more cheerful room appearance. See Figure 2.

### WARPING

In warping rooms, where horizontal warpers are employed, a recommended system is to treat each warper as an individual unit using the "spilled" lighting principle. This requires the same type of luminaire as suggested earlier for weaving. These should be spaced, one over the creel, one over the reed and one over the beam centered in all cases with the width of the machine and use 200-watt, Mazda "C" lamps. One of the factors to consider in warping is that work is done both in a horizontal and vertical plane. The

system suggested will furnish a sufficient intensity of illumination to both surfaces and spill suffiicent light on aisles, and driving gear. Intensities should be about 30 foot-candles on the work and taper off gradually.

If Swiss warpers are installed in the same room with horizontal warpers the same system may be employed for uniform appearance, but where they are set up in a separate part of the mill it has been found more satisfactory to use two units with extensive type reflectors and the same size lamps, due to the more compact form of this type of warper. The creel is smaller, the reed wider and the mill itself not over three yards in circumference, practically eliminating the vertical working plane. Intensity for Swiss warping should be 12 to 15 foot-candles.

### THROWING

The throwing branch of the industry is one requiring very careful consideration when planning the lighting system. Most throwing plants run twenty-four hours per day, which means that the night shift works entirely under artificial illumination.

High intensities are not so necessary because of the nature of the process, as it is a comparatively simple matter to detect broken ends or empty spools. Excellent results have been obtained by using a general system of illumination employing RLM steel dome reflectors with 200-watt bowl enameled lamps spaced 16 to 18 foot-centers and hung 12 to 14 ft. from the floor. This will provide about 4 or 5 foot candles. Higher intensities, which are advisable, are secured by placing two units in each alley, between machines hung 12 ft. from floor, using RLM steel dome reflectors and 200-watt bowl enameled Mazda lamps, giving an intensity of approximately 10 foot-candles.

If glass reflectors are used a pleasing upward component, adding to the appearance of the room, making it more cheerful is secured.

It should not be forgotten, in any event, to provide properly diffused illumination for the entire room including all aisles in order to relieve eye strain.

## DYEING

Another branch of the silk industry that presents quite a problem for the illuminating engineer is in the dye house.

On the basis of a recent investigation a system was installed in a modern dye house.

Because of the humid atmosphere existing in buildings where dyeing is done, vapor-proof enclosing globes should be used to protect lamp base and socket parts from corrosion. Ordinary vapor-proof globes give the same light distribution as bare lamps and do not protect against glare from excessively bright lamp filaments.

For this reason a prismatic glass vapor-proof reflector globe, designed to screw into a cast iron or lead alloy holder containing lamp socket, is often used with 150-watt type "C" clear Mazda lamp.

The distribution produced by this unit has the maximum candle power at 55° from the vertical which provided a uniform intensity on both vertical and horizontal surfaces, a necessary factor. A sharp light cut off at 60° eliminates objectionable glare.

Units spaced in bays 10 x 10 feet and mounted 10 feet from the floor, result in a uniform initial intensity of 12 foot-candles. See Figure 3.

An important point in dyeing is the proper matching of colors. Customers usually send a sample of color wanted or specify shade from Standard Color Card.

For this purpose a small room should be provided so constructed that north skylight will be available. At times when this is not to be obtained or in dark hours, the best sustitute is a unit producing artificial daylight, consisting of a heavy gauge copper hood with a one piece pot glass filter with the color in the glass. Applied color will fade. Regular incandescent lamps are used which are usually supplied with the unit to insure proper size and type.

It is suggested that cheap unreliable substitutes be avoided as the cost of a proper type of color matching unit is made many times by the saving in having goods dyed with proper shades.

## CONCLUSION

Other phases of the silk industry deserve consideration, such as ribbon weaving and Jacquard broad silk weaving, but the machinery in these branches differ widely in various plants, especially with ribbon weaving and it might be suggested to treat each problem as it presents itself; although it might be said that it is almost impossible to use anything else but a well designed local system for either of these branches, except in a very few cases.

In conclusion, it might be added that practically no silk plants can operate without the use of artificial light and when compared with the amount of money represented by the raw and finished material handled in the course of only one year, the cost of the best possible lighting system is very negligible.

# ABSTRACTS

In this section of the TRANSACTIONS there will be used (1) ABSTRACTS of papers of general interest pertaining to the field of illumination appearing in technical journals, (2) ABSTRACTS of papers presented before the Illuminating Engineering Society, and (3) NOTES on research problems now in progress.

## DESIRABLE DISTRIBUTION OF LIGHT AND BRIGHTNESS FOR THE DINING-ROOM

BY M. LUCKIESH* AND MARGARET S. FULLERTON**

An investigation was conducted to ascertain the most desirable distribution of illumination in a typical dining-room, 15′–4″ wide and 21′–6″ long. The walls were of two tones of warm gray, the upper walls being some lighter than the lower. The ceiling was a very light warm gray, commonly termed cream white. The rug was taupe with a suggestion of rose shade. A white cloth was provided for the table and experiments were conducted with and without this cloth. A bowl with brightly colored flowers added a final touch to the table. Reflection-factors of these various areas are presented in Table I.

TABLE I

REFLECTION-FACTORS OF IMPORTANT AREAS

| | Per cent |
|---|---|
| Table (without white cloth) | 15 |
| Table (with white cloth) | 66 |
| Ceiling | 61 |
| Upper Walls | 53 |
| Lower Walls | 45 |
| Rug | 11 |

The fixture used, was so equipped that four steps of illumination were obtained. Step 0 was constant throughout the experiment and consisted of one 75-watt lamp providing "direct" light,

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**Laboratory of Applied Science, National Lamp Works of G. E. Co., Cleveland, Ohio.

confined to the top of the table, and three 25-watt lamps providing a "semi-indirect" component. Step 1 consisted of Step 0 illumination plus three 25-watt lamps providing a component of "indirect" lighting. Step 2 consisted of Step 0 plus three 50-watt lamps providing "indirect" lighting. Step 3 added to the illumination of Step 0 three 25-watt lamps and three 50-watt lamps providing "indirect lighting. Foot-candle readings were taken on the table and on the ceiling at four different points.

TABLE II

ILLUMINATION INTENSITIES ON IMPORTANT AREAS

Foot-Candles

| Step | On table | At various points*on ceiling | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Without cloth on table | | | | With cloth on table | | | |
| | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 0 | 11 | 1.0 | .3 | 0.1 | 0.1 | 2.0 | 0.5 | 0.2 | 0.1 |
| 1 | 12 | 6.0 | 1.9 | 0.4 | 0.4 | 7.0 | 2.2 | 0.5 | 0.5 |
| 2 | 13 | 11.0 | 2.9 | 0.5 | 0.5 | 12.0 | 3.0 | 0.7 | 0.6 |
| 3 | 14 | 16.0 | 4.2 | 0.8 | 0.8 | 17.0 | 4.5 | 1.0 | 0.9 |

*Point 1 was directly over the table and about a foot from the center of the room. Point 2 was about 4 feet from the center of the room. Point 3 was about 6 feet from the center of the room. Point 4 was about 7½ feet from the center of the room.

The brightnesses of the various points of interest are presented in Table III.

TABLE III

BRIGHTNESSES OF VARIOUS SURFACES IN THE ROOM IN MILLI-LAMBERTS

| Step | Without cloth on table | | | | With cloth on table | | | |
|---|---|---|---|---|---|---|---|---|
| | Table | Lower Walls | Upper Walls | Ceiling (Pt. 1) | Table | Lower Walls | Upper Walls | Ceiling (Pt. 1) |
| 0 | 1.72 | —— | —— | 0.66 | 7.75 | 0.1 | 0.11 | 1.3 |
| 1 | 1.94 | 0.19 | 0.28 | 3.98 | 8.5 | 0.21 | 0.32 | 4.5 |
| 2 | 2.04 | 0.29 | 0.39 | 7.2 | 9.15 | 0.32 | 0.48 | 7.85 |
| 3 | 2.26 | 0.39 | 0.52 | 10.76 | 9.9 | 0.43 | 0.57 | 11.19 |

The observer was asked to indicate his preference of these four lightings under each of two conditions, namely with and without a white cloth on the table: and from two viewpoints under these two conditions, namely, at the table and away from the table. When the observer first made his choice there was no white cloth on the table. His preference was determined under this condition with the observer away from the table, taking a general or mental photograph of the room as a whole. Next his preference was

determined when he was seated at the table without a white cloth. The white cloth was then put on the table and the observer asked to state his preference under this condition both away from the table and at the table. Forty observers, male and female, were used but no sex difference was noted. The results are shown in table IV.

TABLE IV

A Summary of References

| Step | Without white cloth | | With white cloth | |
|---|---|---|---|---|
| | Away from table | At table | Away from table | At table |
| 0 | 4 | 3 | 2 | 2 |
| 1 | 10 | 18 | 12 | 15 |
| 2 | 19 | 14 | 23 | 14 |
| 3 | 7 | 5 | 3 | 9 |

According to Table IV when the observer was viewing the room as a whole and there was no white cloth on the dining-table, Step 2 was the most desired although Step 3 was a close second. In Table III, it is seen that under the illumination of Step 2 the table and ceiling are the brightest areas and the walls are less bright. These brightness contrasts are just great enough to give pleasing prominence to the center of the room, namely the table. Its desirability above the other steps is apparently due to the fact that in the other steps, the brightness contrasts are too great. However, from a viewpoint at the table, under this same condition, Step 1 is most preferred.

When the white cloth is added to the dining-table, the same two steps, namely Step 2 when the observer is away from the table and Step 1 when observer is seated at the table, were found to be the most preferred. The percentage of observers choosing these two steps, however, is higher than under the condition without the cloth. That is, the extremes of contrast are even less preferred with a cloth on the table. In Table III it is seen that the white cloth has added enormously to the brightness of the table but not, in proportion, to the other places in the room. This makes the brightness contrast between the table and the other surfaces in the room so great under the extremes of illumination that they rank very low in preference. In Step 1 and Step 2, the brightness contrasts are not as great.

The distribution of brightness determines the pleasantness of surroundings. In this experiment, it is found that the desirable brightness distribution is obtained by the lighting conditions of Step 1 and Step 2, the middle steps of the range shown. The combination of illumination intensities and reflection-factors is responsible for brightness distribution. The experiment shows that in a given dining-room there are definite ratios of upward to downward light which are much more preferred than extremes of this ratio. In another room whose reflection-factors differed greatly, the same range of ratios obviously would not produce the most preferred distribution of brightness. However, in any room there is a ratio of upward to downward light which produces approximately the same brightness distribution as found desirable in this experimental room. In other words, there is always a ratio of upward to downward light which produces a pleasing effect but it varies with the decorative scheme of the room.

# WESTINGHOUSE LAMP COMPANY'S TRAINING COURSE*

BY A. R. DENNINGTON**

Realizing that the future growth of the industry depends upon the men connected therewith, the Management of the Westinghouse Lamp Company has arranged a systematic Training Course for new men entering the Organization.

An Educational Committee consisting of Mr. T. G. Whaling, General Manager, Chairman and Messrs. E. L. Callahan, Sales Manager, H. D. Madden, Supt. of Equipment Dept., R. E. Myers, Chief Engineer and F. M. Wicks, Manager of Works, as members, was appointed by the Advisory Board.

The Educational Committee, after careful consideration of the needs of the Company, recommended the organization of a Training Course covering a period of three months for general instruction in lamp manufacture and supplemented by three months of training along commercial lines, for salesmen, or along manufacturing lines for men taking up work relating to lamp production and development.

Schedules covering each week of the training period were made up and are being put into effect, so that each student is transferred to a new phase of the work at regular intervals. The student's observations on each assignment during the first three months are directed by a series of questions and note books are provided in which he is encouraged to write the salient facts he has learned.

The Course is planned to give men taking up commercial activities, actual training with agents, thus extending to sales work the practical experience method which has been successfully used in the past in training men for manufacturing and engineering work.

*Owing to the increased interest in the training of Illuminating Engineers and Lighting Salesmen by the Central Stations, this brief note is very timely.—*Committee on Editing and Publication.*

**In charge of Educational Department, Westinghouse Lamp Co., New York, N. Y.

During the week July 30th to August 4th, when the manufacturing divisions were closed, a special schedule consisting principally of lectures, was arranged and speakers from outside, as well as within the organization, gave talks on various subjects relating to illumination and the commercial phases of the incandescent lamp business. As this forms a somewhat unusual plan for giving men who have recently joined the Organization special instruction, which should be helpful to them and to the Company, the schedule for the week is given:

TRAINING COURSE SCHEDULE: JULY 30TH TO AUG. 4TH, INCLUSIVE

*Monday, July 30th.*

8:45 A. M.—"Fundamentals of Illumination", Mr. C. M. Doolittle, Illumination Bureau.

10:00 A. M.—"Work of our Syndicate Department," Mr. Fred Kinsey, Mgr.

1:00 P. M.—"Merchandising Department," Mr. P. C. Pfenning, Mgr.

3:00 P. M.—"Work of Illumination Bureau," Mr. S. G. Hibben, Mgr.

*Tuesday, July 31st.*

8:45 A. M.—"Lighting Specifications and the Foot Candle Meter," Mr. S. G. Hibben.

10:00 A. M.—"Electrical Testing Laboratories Inspection Service," Mr. Preston S. Millar, Gen. Mgr.

1:00 P. M.—"Calculation of Illumination for Office."

*Wednesday, August 1st.*

8:45 A. M.—"Store Window Lighting," Mr. D. W. Atwater, Illumination Bureau.

10:00 A. M.—"Show Window Trimming," Mr. R. MacWilliams," Adv. Dept.

1 P. M.—"Calculation of Illumination for Factory."

*Thursday, August 2nd.*

8:45 A. M.—"Illumination from Central Station Standpoint," Mr. W. T. Blackwell, Illuminating Engineer, Public Service Electric Co.

10:00 A. M.—"George Cutter Equipment," Mr. C. H. Stahl, Illuminating Engineer, George Cutter Works.

1:00 P. M.—"Merchandising of Westinghouse Elec. & Mfg. Co.," Mr. M. C. Turpin, Mgr. Sales Promotion Section, W. E. & M. Co.

3:00 P. M.—"Interior Store Arrangement," Mr. R. B. Ely, Mdse. Div.

*Friday, August 3rd.*

8:45 A. M.—"Commercial Engineering Problems," Mr. A. E. Snyder, Asst. to Commercial Engineer.

10:00 A. M.—"Lighting Units and Glasswares," Mr. S. G. Hibben.

1:00 P. M.—"Salesmanship," Mr. F. W. Loomis, Illuminating Engineer, Duquesne Light Company.

2:00 P. M.—"Sales Experience,"—Mr. R. G. Reynolds, Alexander Hamilton Institute.

3:00 P. M.—"Calculation of Illumination for Drafting Room."

*Saturday, August 4th.*

8:45 A. M.—"Calculation of Illumination for Street Lighting."

All schedules are arranged with the idea of giving the student a broad view of the business and getting him to appreciate the correlation of the work of the various sections and the great advantage of cooperation, to individuals as well as to departments.

Two lectures are scheduled for each week of the entire Training Course. One of these lectures is to cover a manufacturing subject and one is to relate to some commercial matter. These will be given by a department head or by others who are qualified to talk upon the subject chosen.

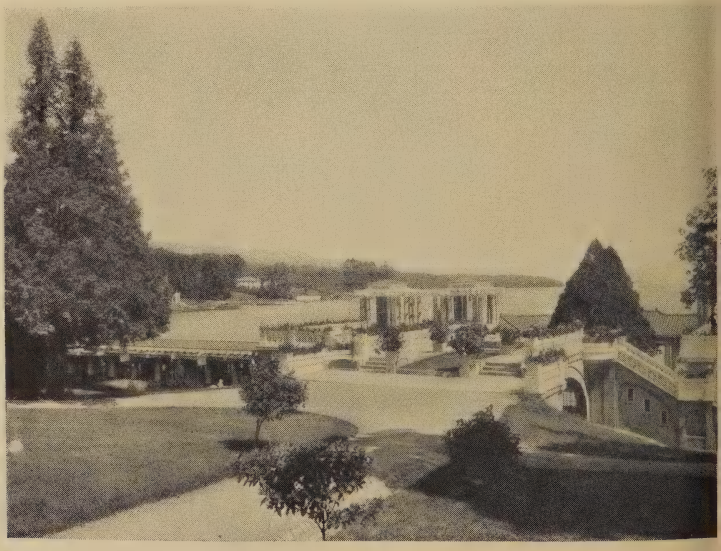
The students are under the direction of foremen or those wh are duly qualified in the section in which the students are assigned Reports on the students' activity, interest, application and othe general characteristics are made by the foreman at the end of th assignment in each section. These reports are summarized in th Educational Department, on a record blank, for each student. Th file of student records is open for inspection by anyone, includin the students. In this way each student may see what record h has made and is encouraged to correct any undesirable traits h may possess.

Though the Training Course has been arranged to meet th needs of men graduating from college, it is equally adaptable fo men who have satisfactory qualifications, especially for sales work even though they may not have had the advantages of colleg training.

The visitor's first glimpse of Lake George, when approaching by motor or railroad train. The lake is 40 miles in length and contains hundreds of beautiful islands.

Fort William Henry Hotel, Headquarters of 17th Annual Convention, situated on shore of Lake George facing up the lake between high rows of imposing mountains.

View of Lake George to the north as seen from the verandas of the hotel.



The Formal Garden and Pergola with adjoining buildings, in which are housed a gift shop, tea-room, and sun parlors.

# SOCIETY AFFAIRS

## CONVENTION NOTES

The Seventeenth Annual Convention of the Society will be held at the Fort William Henry Hotel, Lake George, N. Y., September 24, 25, 26, 27 and 28, 1923.

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### GENERAL CONVENTION COMMITTEE

W. D'A. Ryan, *Chairman*
H. W. Peck, *Vice-Chairman*
H. E. Mahan, *Secretary*

Alexander Anderson
B. S. Beach
N. R. Birge
W. T. Blackwell
S. H. Blake
H. Calvert
A. D. Cameron
Julius Daniels
E. Y. Davidson, Jr.
S. E. Doane
F. H. Gale
Samuel G. Hibben
Preston S. Millar
G. Bertram Regar
W. L. Robb
W. M. Skiff
J. L. Stair
C. P. Steinmetz
G. H. Stickney
D. B. Taylor
R. B. Thompson
E. D. Tillson
C. D. Wagoner
H. F. Wallace
F. H. Winkley
L. A. S. Wood

### SUB-COMMITTEES

*Entertainment*

A. D. Cameron, *Chairman*
N. R. Birge
S. H. Blake
C. A. B. Halvorson

*Publicity*

A. F. Dickerson, *Chairman*
B. S. Beach
R. C. Rodgers
C. D. Wagoner

*Finance*

F. H. Winkley, *Chairman*
Alexander Anderson

*Attendance and Transportation*

J. F. Anderson
W. T. Blackwell
H. Calvert
L. C. Conant
G. G. Cousins
Julius Daniels
C. G. Eichelberger
G. F. Evans
F. A. Gallagher, Jr.
K. W. Mackall
Preston S. Millar
C. C. Munroe
G. B. Regar
W. M. Skiff
Frank C. Taylor
E. D. Tillson
L. E. Voyer

## PROGRAM

MONDAY, SEPTEMBER 24, 1923

10:00 A. M. to 12:30 P. M. ..... Registratio
2:00 P. M. to 5:00 P. M. ..... General Sessio
Evening ..... Entertainment and Informal Danc

TUESDAY, SEPTEMBER 25, 1923

9:00 A. M. to 12:00 P. M. ..... Papers Sessio
2:00 P. M. to 5:00 P. M. ..... Papers Sessio
Evening ..... A Night of Light and Colo

WEDNESDAY, SEPTEMBER 26, 1923

9:00 A. M. to 11:45 A. M. ..... Papers Sessio
12:30 P. M. ..... Motor Trip and Lunch in Wood
Evening ..... Papers Sessio

THURSDAY, SEPTEMBER 27, 1923

9:00 A. M. to 12:00 M. ..... Papers Sessio
2:00 P. M. to 5:00 P. M. ..... Papers Sessio
Evening ..... Banque

FRIDAY, SEPTEMBER 28, 1923

9:00 A. M. ..... Section Development Conferenc

No special entertainment program has been planned for Friday, Septem ber 28th, but opportunity will be afforded the delegates and guests to mak inspection trips to Fort Ticonderoga, Saratoga Springs, Albany, Schenectad (including the General Electric Co. Works and the Illuminating Engineerin Laboratory) and other points of interest.

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## 1923 CONVENTION PAPERS PROGRAM

MONDAY AFTERNOON, SEPTEMBER 24, 2:00 P. M.

Address of Welcome, Hon. George R. Lunn
Response to Address of Welcome
President's Address, WARD HARRISON
Survey of the year's work—Report of General Secretary, SAMUEL G. HIBBEN
The Year's Progress in Illumination—Report of Committee on Progress, F. E. CADY, *Chairman*
Twelve Solutions of a Street Lighting Problem

TUESDAY MORNING, SEPTEMBER 25, 9:00 A. M.

Pageant Street Lighting, SAMUEL G. HIBBEN
The Relation of Illumination to Production, D. P. HESS and WARD HARRISON
Salient Features in Power Station Lighting, R. A. HOPKINS

TUESDAY AFTERNOON, SEPTEMBER 25, 12:30 P. M.

Boat Trip with Session of Committee Reports

Motor Vehicle Lighting Regulations—Committee on Motor Vehicle Lighting, CLAYTON H. SHARP, *Chairman*

Recent Developments in Nomenclature and Standards—Committee on Nomenclature and Standards, E. C. CRITTENDEN, *Chairman*

Progress of the Tentative Code of Luminaire Design—Committee to Cooperate with Fixture Manufacturers, M. LUCKIESH, *Chairman*

How to Make the I. E. S. a Truly National Body—Committee on New Sections and Chapters, D. MCFARLAN MOORE, *Chairman*

TUESDAY EVENING, SEPTEMBER 25, 7:45 P. M.

A Night of Light and Color

"Light"—The Designer, M. LUCKIESH

Outdoor Spectacular Lighting Display

WEDNESDAY MORNING, SEPTEMBER 26, 9:00 A. M.

Research Problems—Report of Committee on Research, E. F. NICHOLS, *Chairman*

Visibility of Radiant Energy, K. S. GIBSON and E. P. T. TYNDALL

Some Experiments on the Speed of Vision, PERCY W. COBB

The Colorimetry and Photometry of Daylight and Incandescent Illuminants, I. G. PRIEST

Further Studies of the Effect of Composition of Light on Important Ocular Functions, C. E. FERREE and G. RAND

WEDNESDAY EVENING, SEPTEMBER 26, 7:30 P. M.

Artificial Illumination in the Iron and Steel Industry, W. H. RADAMACHER

Working with the Architect on Difficult Lighting Problems, Messrs. A. D. CURTIS and J. L. STAIR

Railway Car Lighting, G. E. HULSE

Depreciation of Lighting Equipment due to Dust and Dirt, E. A. ANDERSON

THURSDAY MORNING, SEPTEMBER 27, 9:00 A. M.

Determination of Daylight Intensity at a Window Opening, Report of Committee on Sky Brightness, H. H. KIMBALL, *Chairman*

Daylighting from Windows, H. H. HIGBIE and G. W. YOUNGLOVE

Some Principles Governing Proper Utilization of the Light of Day in Roof Fenestration, W. S. BROWN

Lighting for School Buildings—Preliminary Draft of Revised Code, Report of Committee on Lighting Legislation, L. B. MARKS, *Chairman*, and Sub-Committee on School Lighting, M. LUCKIESH, *Chairman*

THURSDAY AFTERNOON, SEPTEMBER 27, 2:00 P. M.

Colored Light, by M. LUCKIESH and A. H. TAYLOR

Production and Growth in Plants under Artificial Illumination, R. B. HARVEY

The Response of Plants to Artificial Lighting, HUGH FINDLAY

Unit Costs of Industrial Lighting, DAVIS H. TUCK

Testing Colored Material for Fastness to Light, H. S. THAYER

FRIDAY MORNING, SEPTEMBER 28, 9:00 A. M.

There will be held a Section Development Conference for Officers a Committee Chairmen of Sections and Chapters and all others interested.

## ENTERTAINMENT

The entertainment features of the convention will include automob trips to points of historic interest, a boat ride on Lake George, and a mot trip to Tripp Lake Lodge with luncheon in the woods.

For those who play golf, tournaments have been arranged at a time whi will n ot conflict with the regular business sessions. Cards, teas, motor-bo trips, and a musical for the ladies are also included in the program. The ba quet will be held Thursday night, to which all delegates to the conventi are invited.

The Entertainment Committee has planned several novel features whi will be in the nature of surprises.

The advanced registration indicates that this will probably be the large convention in the history of the Society. Inasmuch as the committee is ma ing special arrangements for the ladies, it is hoped that delegates will bri their wives where possible.

## CONVENTION BRIEFS

Tuesday evening has been set aside as "A Night of Light and Color."

Detailed plans for special lighting have been completed and promise surpass in spectacular effect and all around interest anything yet attempt by the Society. A battery of great searchlights forming a scintillator of movi colored beams, will be the big event of the Convention. This scintillator w be located on the wharf in front of the Fort William Henry Hotel, and w send a multitude of powerful rays into the sky in a fan-like formation. means of colored slides and a well drilled corps of operators, the beams w be constantly changed in colors, one blending into another to give a startli and beautiful rainbow effect.

An elaborate program of fireworks is another feature, a high point of whi will be the explosion of the largest bomb used in such displays. A jewel emblem of the Society, illuminated in various colors by floodlights is anoth thing of interest on which the Committee is working. This will be placed the ground near the hotel.

There should not be a dull moment for the ladies as automobile rid dancing, golf contests, teas, motor-boat rides, musicales, bridge tournamer and other features have been prepared for their entertainment.

The Philadelphia Section wishes to formally advise all other Sections th it intends to take the attendance prize at the national convention at La George, N. Y. The Cleveland Chapter won the prize, a silver-band gav

last year and have sent word that it will be retained by them this year. The New York and New England Sections promise large delegations, and also the Chicago Section will be well represented. Canada will send a number of delegates from the Toronto Chapter.

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During the evenings of late September at Lake George light-weight overcoats and wraps will be needed.

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## SECTION ACTIVITIES

### CLEVELAND CHAPTER

The following men have been elected as officers of the Cleveland Chapter for the coming year:

Chairman, Prof. H. B. Dates; Secretary, Robert A. Fulton; Chairman Papers Committee, E. W. Commery; Board of Managers, H. L. Wright, C. L. Dows, J. W. Beam, E. W. Commery, P. C. Pfenning.

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## NEWS ITEMS

At the annual convention of the Nation Council of Lighting Fixture Manufacturers, held in Buffalo, June 26 to 28, Mr. Herman Plaut, of New York, was elected president for the ensuing year.

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Capt. D. W. Blakeslee, Electrical Engineer, Jones & Laughlin Steel Corporation, Pittsburgh, Pa., married Miss Margaret K. Steel of Pittsburgh on June first.

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Mr. Frederick J. McGuire, of the Department of Water Supply, Gas, and Electricity, New York City, has again planned, in cooperation with the Department of Education, to continue this year classes of instruction in "Practical Artificial Lighting" in the evening trade schools in Brooklyn and in New York.

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## GENERAL OFFICE NOTES

A new Membership List was published during the summer, which is a revision of the 1919 list. Reply postal cards were sent to every member and only a small percentage were returned to the General Office. Care was taken to make the new list as accurate as possible. A number of errors have been reported, and it is requested that members advise the General Secretary immediately of any change of address, or other items that should be corrected.

An errata page will be included in a future issue of the TRANSACTIONS.

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TRANSACTIONS for October, November and December, 1922, and January, February, March, April and May, 1923, are out of print. Please advise the General Secretary of any of these issues for sale and price will be quoted.

# COUNCIL NOTES

## ITEMS OF INTEREST

At the meeting of the Executive Committee on July 27, 1923 the followin were elected to membership:

### Two Members

HATCH, B. E., Westinghouse Elec. & Mfg. Co., 1442 Widener Bldg., Philadel phia, Pa.

SAVAGE, ARTHUR H., A. H. Savage Co., 914 Pioneer Bldg., St. Paul, Minn.

### Eighteen Associate Members

ALEXANDER, GEORGE L., International General Electric Co., Schenectady N. Y.

BELL, HOWARD H., General Electric Co., Schenectady, N. Y.

BOTSFORD, C. J., Westinghouse Lamp Co., 165 Broadway, New York, N. Y

FUCHS, THEODORE, JR., Edison Lamp Works, Harrison, N. J.

GAWAN, LOUIS B., Utah Power & Light Co., 132 Main St., Salt Lake City Utah.

GOTTSCHE, A. L., Westinghouse Elec. & Mfg. Co., George Cutter Works South Bend, Ind.

HILL, GEORGE A., National X-Ray Reflector Co., 235 W. Jackson Blvd., Chi cago, Ill.

HOWARD, HAROLD W., General Electric Co., Schenectady, N. Y.

KINNEY, RAYMOND C., Western Electric Co., Hawthorn Plant, Dept. 6723 Chicago, Ill.

LABELLE, PHILIP R., Shawinigan Water & Power Co., 621 Power Bldg., Montreal, Quebec, Canada.

NORRIS, B. H., General Electric Co., Schenectady, N. Y.

PROFFATT, CHARLES P., Universal Elec. Co., 701 Asbury Ave, Ocean City, N. J.

SIMONS, S. A., Save Electric Corp., 254–36th St., Brooklyn, N. Y.

SWEENEY, GEORGE J., United Elec. Light & Power Co., 514 W. 147th St., New York, N. Y.

WERNERT, A. L., Texas Central Power Co., 1st Nat'l Bank Bldg., San Antonio, Tex.

WILSON, EDWIN S., Philadelphia Electric Co., 3100 Kensington Ave., Phila delphia, Pa.

WINKLER, CLEM R., Arkansas Central Power Co., 115 W. 4th St., Little Rock, Ark.

ZIEME, HARRY, Penn Public Service Corp., 222 Levergood St., Johnstown, Pa.

### Two Sustaining Members

Frink, I. P., Inc., 24th St. & 10th Ave., New York, N. Y.
William H. Spencer, Official Representative.

Western Electric Co., 195 Broadway, New York, N. Y.
E. J. Dailey, Jr., Official Representative.

The General Secretary reported the deaths of two Associate Members: L. H. Plaisted, Columbus Railway Power & Light Co., Columbus, Ohio; C. A. Strong, 79 Milk Street, Boston, Mass.

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At the meeting of the Executive Committee on August 30, 1923, the following were elected to membership:

**Two Members**

Bergman, Axel G., Ordnance Engineering Corp., 170 Broadway, New York.
Wible, Harvey M., Westinghouse Elec. & Mfg. Co., George Cutter Works, South Bend, Ind.

**Eleven Associate Members**

Allen, Francis P., Elec. Light & Power Co., of Abington, 64 Charles Street, N Abington, Mass.
Bremmer, R. C., Pacific States Elec. Co., 61 North 5th St., Portland, Ore.
Dudley, M. E., M. E. Dudley Co., 1044 Garfield St., Lincoln, Neb.
Glass, David Hasler, Jr., Buick Motor Co., 604 Garland St., Flint, Mich.
Gowdy, Robert Clyde, University of Cincinnati, Cincinnati, Ohio.
Johnson, Wilber M., National Lamp Works of G. E. Co., Nela Park, Cleveland, Ohio.
Kent, Charles N., 12 East 46th St., New York, N. Y.
Smith, Harold C., Catton Neill & Co., Fort St. & Beretania, Honolulu, Hawaii.
Thompson, Willard W., Hixon Electric Co., 308 Dover St., Boston, Mass.
Tracy, Charles R., Penn. & Ohio Power & Light Co., P. O. Box 58, Youngstown, Ohio.
Wright, George Ellery, University of Illinois, Urbana, Ill.

**One Transfer to Full Membership**

Alden, Walter A., Westinghouse Elec. & Mfg. Co., 420 S. San Pedro St., Los Angeles, Calif.

**One Transfer to Associate Membership**

Nodell, W. L., 1405 Eighth Ave., Brooklyn, N. Y.

# ILLUMINATION INDEX

PREPARED BY THE COMMITTEE ON PROGRESS

An INDEX OF REFERENCES to books, papers, editorials, news and abstracts on i
nating engineering and allied subjects. This index is arranged alphabetically acc
to the names of the reference publications. The references are then given in or
the date of publication. Important references not appearing herein should be
to the attention of the Illuminating Engineering Society, 29 W. 39th St., New
N. Y.

| | AUTHOR | DATE |
|---|---|---|
| **American Architect & Architectural Review** | | |
| Daylight in Buildings—I | Percy E. Nobbs | July 4 |
| Daylight in Buildings—II | Percy E. Nobbs | Aug. 1 |
| **American Journal of Ophthalmology** | | |
| Intensity of Stimulus and Size and Shape of Color Fields | C. E. Ferree and G. Rand | June |
| **American Journal of Ophthalmology** | | |
| Conservation of Vision | | July |
| Effect of Increase of Intensity of Illumination on Acuity and Intensity of Illumination of Test Charts | C. E. Ferree and G. Rand | Aug. |
| Variations in Normal Visual Acuity in Relation to the Retinal Cones | Alfred Corvan | Aug |
| **American Journal of Physiological Optics** | | |
| The Nature of Light | Planck | July |
| A New Theory of Vision | Schanz | July |
| **American Journal of Physiology** | | |
| The Sensibility of the Eye to Differences in Wave-Length | Henry Laurens and W. F. Hamilton | Aug. 1 |
| The Sensibility of the Eye to Differences in Wave-Length in Relation to Color Blindness— | W. F. Hamiltom and Henry Laurens | Aug. 1 |
| **Annalen der Physik** | | |
| Die Spektralanalyse der seltenen Erden | J. M. Eder | May 23 |
| **Architectural Forum** | | |
| The Lighting of Banks | A. L. Powell | June |
| **Central Station** | | |
| Better Lighting of Drug Stores | Walter Sturrock | June |
| Highway Lighting of Vital Interest to Central Stations | W. R. Huntley | July |
| Street Lighting for the Small City | G. E. McNair | Aug. |

*Not previously reviewed.

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|---|---|---|
| Elimination of Glare and Shadows Prerequisites in Lighting Automobile Display Rooms— | | July |
| Lincoln Memorial Fountains to be Lighted | | Aug. |
| Local Lighting Supplemented with General Overhead System (for machine shop)— | | Aug. |
| Keep Colored Lamps Clean | | Aug. |
| Reflecting Units Installed on Tops of Showcases Produce Interesting Lighting Installation— | | Aug. |
| **Electrical Review** | | |
| Electro-farming (lighting), | R. B. Matthews | May 25 |
| Lifeboat Illumination— | | May 25 |
| Industrial Lighting | | June 8 |
| A Lighting Service Department | | July 27 |
| **Electrical Times** | | |
| Street Lighting in Bendigo | | May |
| **Electrical Times** | | |
| Workshop Lighting— | | June 21 |
| Neon Tube Lighting— | | June 28 |
| **Electrical** | | |
| Electricity at the Shriners' Convention | | June 23 |
| City Zoning of Street Lighting | Chas. J. Stahl | June 30 |
| Better Lighting Increases Production 35% | | June 30 |
| An Argument for Better Street Lighting | | June 30 |
| Opportunity in the Extension of Highway Lighting | | June 30 |
| Canada to Separate Lighting and Heating Figures | | June 30 |
| Architect and Electrical Engineer (Lighting) | M. M. Samuels | July 7 |
| Working Together for Improved Lighting | (Editorial) | July 7 |
| Life Tests and Inspection of Electric Lamps | | July 21 |
| Manufacture of Lamp Bulbs | G. Gehlhoff | July 21 |
| Department Store Illumination | | Aug. 4 |
| Los Angeles Improving Its Lighting System | | Aug. 4 |
| Lighting the Air Mail Path | | Aug. 11 |
| **Electragist** | | |
| Modern Window Lighting— | | Aug. |
| Cincinnati Fall Festival (Lighting)— | | Aug. |
| **Electrician** | | |
| The Use of Reflectors— | | May 25 |
| Renewing Electric Lamps— | E. Gamba | May 25 |
| Progress in Industrial Lighting— | | June 8 |
| A New Vogue in Lighting Equipment | | June 8 |

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|---|---|---|
| Untersuchungen über die Lage und Dicke der Linse im menschlichen Auge bei physiologischen und pathologischen zuständen, nach einer neuen Methoden gemessen—II. Die Lage der Linse bei glaukomatösen zuständen | J. G. Raeder | June 22 |
| **Helios** | | |
| Moderne Strassenbeleuchtung— | Johannes Schaer | June 10 |
| Neuere Filmbeleuchtungslampen— | | June 10 |
| **Illuminating Engineer** (London) | | |
| The Need for Suitable Training in Illuminating Engineering— | C. E. Greenslade and J. E. S. White | Feb. |
| The Projection of Light | W. J. Jones and E. A. Marx | Mar. |
| Researches on Kinema Projectors— | | Mar. |
| Lighting of Monuments— | | Mar. |
| Railway Signal Lighting with Gas— | | Mar. |
| Data on Lamps in Germany | | Mar. |
| Floodlighting of a War Memorial | | Mar. |
| **Industrial Management** | | |
| Eyesight Conservation in Industry— | Reginald Gordon | June |
| **Journal of American Institute of Electrical Engineers**— | | |
| Fluted Reflectors for Automobile Headlamps— | | July |
| The Quality of Incandescent Lamps— | John W. Howell and Henry Shroeder | Aug. |
| Incandescent Lamp Life Tests— | | Aug. |
| **Journal of Biological Chemistry** | | |
| Fat-soluble vitamine. XIII. Light in its relation to ophthalmia and growth— | H. Steenbock and E. M. Nelson | June |
| **Journal of Electricity** | | |
| Intensive Street Lighting Plan Started for San Diego— | | Aug. 1 |
| **Journal of Franklin Institute** | | |
| The Relation between Field Brightness and the Speed of Retinal Impression— | Percy W. Cobb | June |
| Animal Luminescence— | E. N. Harvey | July |
| A Relation between the Brightness and Hiding-Power of White Paint-Pigments | A. H. Pfund | July |
| The Sense of Verticality and Its Application to Lighthouse Work— | H. de Miffoms | July |
| **Journal of Physical Chemistry** | | |
| The Scattering of Light by Dust-free Liquids: Changes of Temperature— | W. H. Martin and S. Lehrman | June |

| | | |
|---|---|---|
| A low voltage, low wattage mercury lamp— | E. L. Harrington | June |
| The luminescence of incandescent titanium oxide— | E. L. Nichols | June |
| Phosphorescence caused by active nitrogen– | E. P. Lewis | June |
| **Physikalische Berichte** | | |
| Photometerpapiere mit hoher Grun-Gelbempfindlichkeit fur photographische Photometrie— | J. M. Eder | May 1 |
| The measurement of colour | L. C. Martin | May 1 |
| Über Lumineszenz bei chemischen Reaktionen— | H. Zocher and H. Kautsky | June 15 |
| Über Lumineszenzzentren und Veranderungen des Gasdruckes in Spektralrohren bei elektrischen Entladungen, II— | L. Hamburger | June 15 |
| La theorie de Th. Young sur la vision des couleurs— | M. Tscherning | June 15 |
| **Physikalische Zeitschrift** | | |
| Kolorimetrische Untersuchungen— | O. Meissner | May 15 |
| **Physiological Abstracts** | | |
| The action of artificial sunlight on metabolism— | W. Lasch | Apr. |
| **Popular Mechanics Magazine** | | |
| Airplane Mail Service Across the Continent (lighting for)— | | July |
| Swedish Progress Show Aglow with Lights— | | Aug. |
| **Psychological Bulletin** | | |
| Lässt sich das retinale Sehen* rein physikalisch erklären?— | L. Koeppe | July |
| Uber Theorien des Farbensinns*— | H. Köllner | July |
| Das Sehen der Farben*— | F. Schanz | July |
| **Railway Signal Engineer** | | |
| Electric Lights for Signal Indication— | | June |
| **Revue d'Optique** | | |
| Les piles photoelectriques et leur application a la photometrie— | G. Rougier | Apr. |
| **Revue Generale de l'Electricite** | | |
| L'Exposition du Luminaire electrique— | | June 9 |
| **Science** | | |
| Fluorescence in the Cyanophyceae and Diatomaceae— | F. E. Lloyd | Aug. 3 |
| **Science Abstracts—A** | | |
| Electric Arc to Mercury with a Perforated Kathode— | A. Sellerio | May 25 |

*Not previously reviewed.

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|---|---|---|
| II. Uber den Einfluss der Abkühlung der Farbstoffe auf die Absorption des Liches | P. Lasareff | Band 100 |
| Über Verfärbung und Lumineszenz durch Becquerelstrahlen— | Stefan Meyer and Karl Przibram | Band 100 |
| Zur physikalischen Chemie des Farbensehens— | Fritz Weigert | Band 100 |
| **Zeitschrift für technische Physik** | | |
| Lumineszenzerschiemungen und ihre Beziehungen zur Technik— | F. Schroter | No. 4, 1923 |
| Eine Farbenmesser und sein Gebrauch fur Ostwalds Farbenlehre— | L. Block | No. 4, 1923 |
| **Zeitschrift für wissenshaften Photographie und Photochemie** | | |
| Photometrische und spektralphotometrische Studien, I. Die Lichtschwächung durch Reflexion und ihre Anwendung in der Spektralphotometrie— | Karl Schaum | June 16 |

# OFFICERS & COUNCIL

## 1922-23

### President

WARD HARRISON,
Nela Park,
Cleveland, Oho
*Term expires Sept. 30, 1923*

### Junior Past-Presidents

GEO. H. HARRIES
208 South LaSalle Street,
Chicago, Ill.
*Term expires Sept 30, 1923*

GEO. S. CRAMPTON,
1819 Walnut Street,
Piladelphia, Pa.
*Term expires Sept. 30, 1924*

### Vice-Presidents

F. M. FEIKER,
36th Street and 10th Avenue,
New York, N. Y.
*Term expires Sept. 30, 1923*

O. L. JOHNSON,
230 South Clark Street
Chicago, Ill.
*Term expires Sept. 30, 1924*

WM. J. DRISKO,
Mass. Inst. of Technology,
Cambridge, Mass.
*Term expires Sept. 30, 1924*

G. BERTRAM REGAR,
1000 Chestnut Street,
Philadelphia, Pa.
*Term expires Sept. 30, 1924*

### General Secretary

SAMUEL G. HIBBEN,
165 Broadway,
New York, N. Y.
*Term expires Sept. 30, 1923*

### Treasurer

L. B. MARKS,
103 Park Avenue,
New York, N. Y.
*Term expires Sept. 30, 1923*

### Directors

*Terms expire Sept. 30, 1923*

WALTON FORSTALL,
1401 Arch Street,
Philadelphia, Pa.

ADOLPH HERTZ,
rving Place and 15th Street,
New York, N. Y.

FRANK S. PRICE,
160 Pearl Street,
Boston, Mass.

*Terms expire Sept. 30, 1924*

F. C. CALDWELL,
Ohio State University,
Columbus, Ohio

AUGUSTUS D. CURTIS,
235 W. Jackson Blvd.
Chicago, Ill.

PRESTON S. MILLAR,
80th St. and East End Ave.,
New York, N. Y.

*Terms expire Sept. 30, 1925*

FRANK R. BARNITZ,
130 East 15th St.,
New York, N. Y.

CLARENCE L. LAW,
Irving Place and 15th Street,
New York, N. Y.

A. L. POWELL,
Fifth and Sussex Sts.
Harrison, N. J.

# SECTION & CHAPTER OFFICERS

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## 1922-1923

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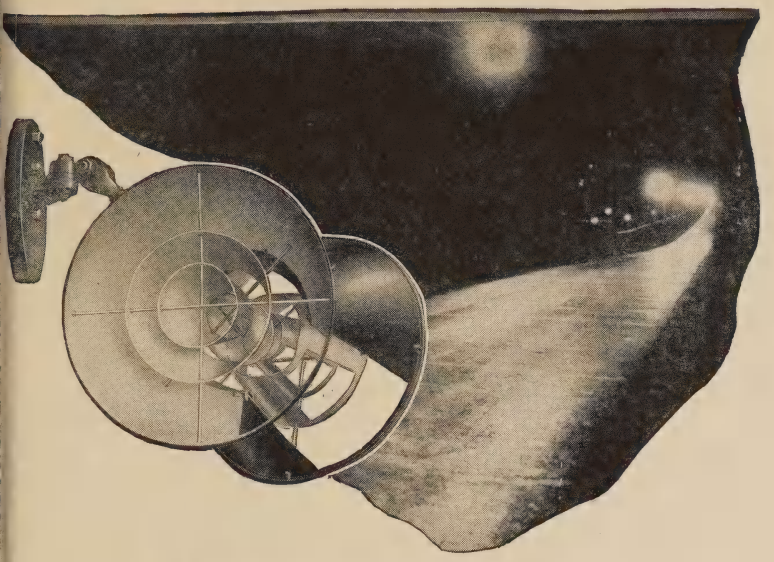

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